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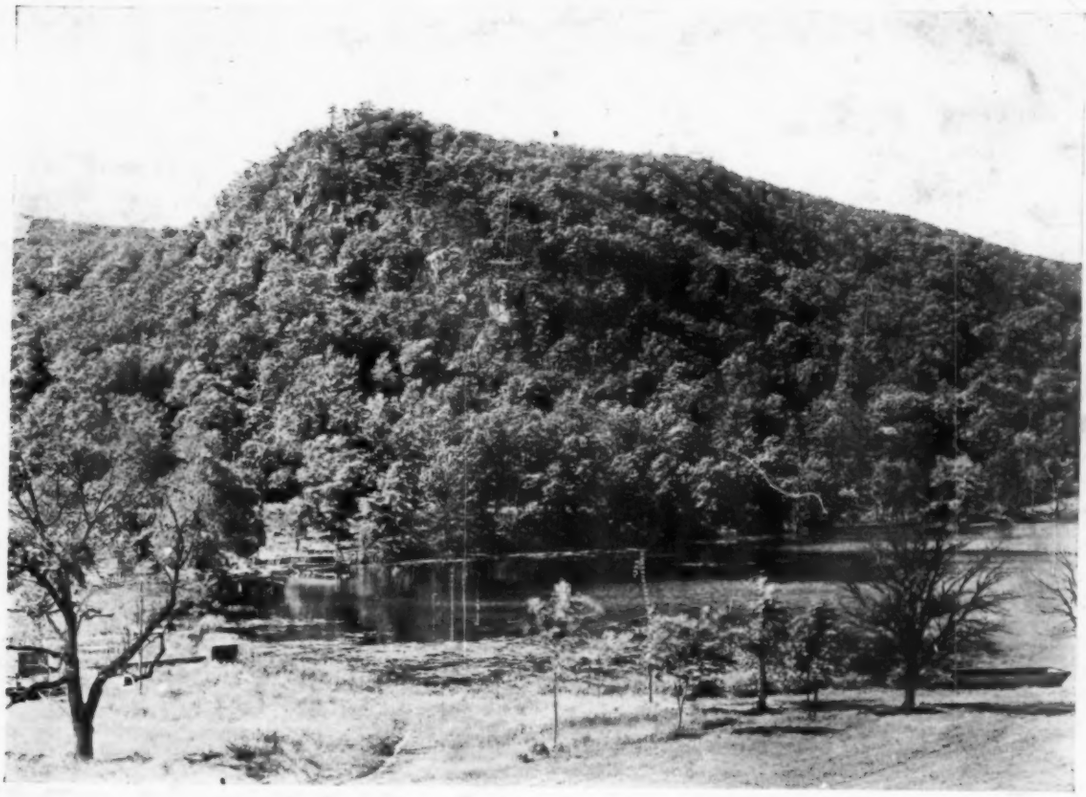


PICATINNY PEAK, PICATINNY ARSENAL, DOVER, N. J.

PICATINNY ARSENAL
Maj. N. F. Ramsey, Ord. Dept., U. S. A.

THE PICATINNY ARSENAL POWDER FACTORY
Maj. F. H. Miles, Jr., Ord. Dept., U. S. A.

FUZES
H. M. Brayton

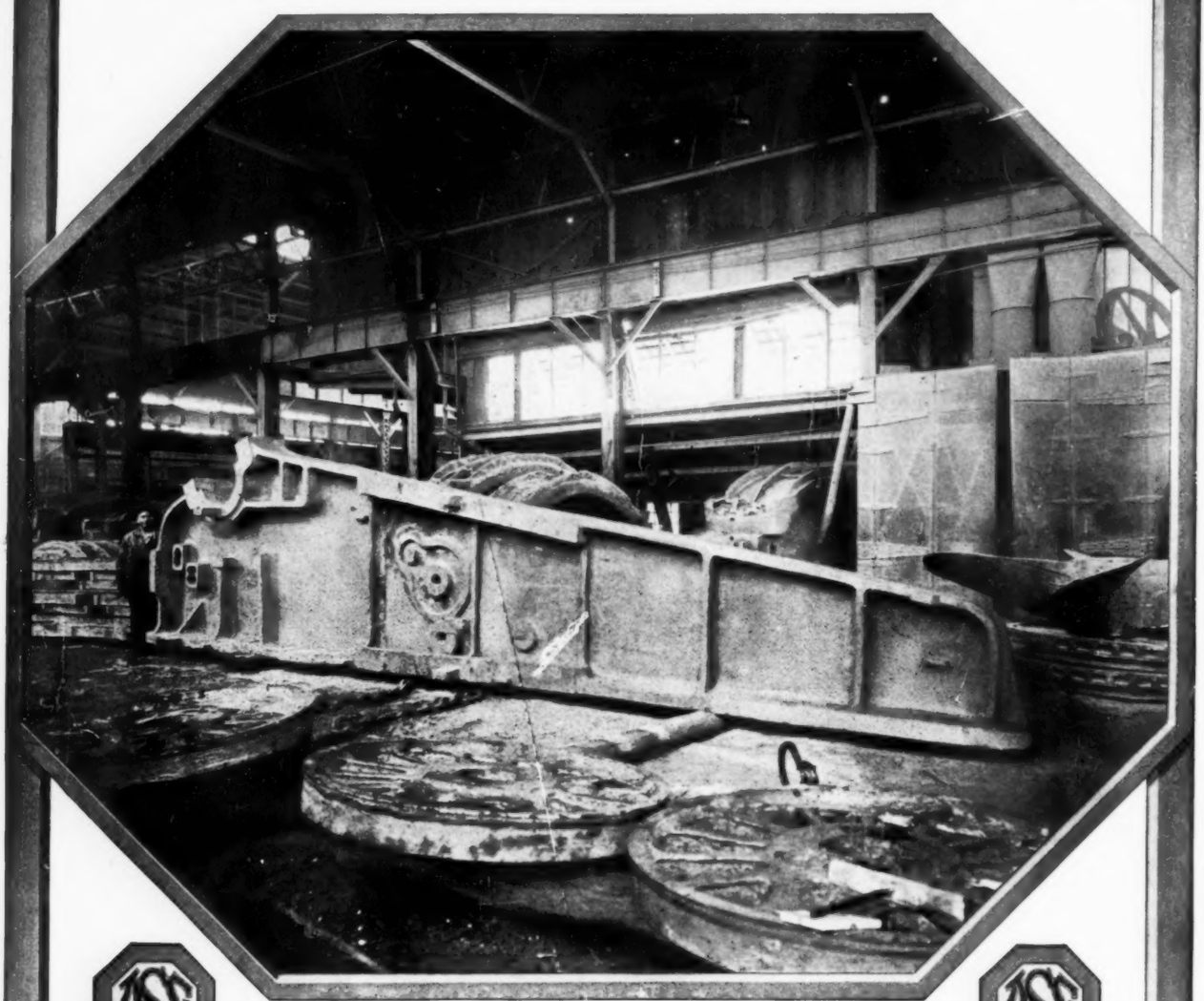
PYROTECHNICS
Capt. I. A. Crump, Ord. Dept., U. S. A.

HIGH EXPLOSIVES
C. J. Bain

LOADING AMMUNITION AT PICATINNY ARSENAL
Capt. J. P. Harris, Ord. Dept., U. S. A.

THE JOURNAL OF THE ARMY ORDNANCE ASSOCIATION

AMERICAN STEEL FOUNDRIES



STEEL CASTINGS
OF EVERY DESCRIPTION
FOR
ARMY AND NAVY REQUIREMENTS

NEW YORK CHICAGO ST. LOUIS

ARMY ORDNANCE

THE JOURNAL OF THE ARMY ORDNANCE ASSOCIATION
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Pledged to Public Service in Effecting Industrial Preparedness for War as Our Strongest Guarantee of Peace

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VOL. VII. JULY-AUGUST, 1926. No. 37.

TABLE OF CONTENTS

PAGE

Announcement: Eighth Annual Meeting, Army Ordnance Association ..... Frontispiece

Picatinny Arsenal 1
MAJ. N. F. RAMSEY, Ord. Dept., U. S. A.

Pittsburgh Ordnance Officials Witness High Explosive Shell Test 5

Military Staff, Picatinny Arsenal, 1926 6

Civilian Staff, Picatinny Arsenal, 1926 7

Among the Pioneers at Picatinny Arsenal Powder Factory 8

The Picatinny Arsenal Powder Factory 9
MAJ. F. H. MILES, JR., Ord. Dept., U. S. A.

Research Activities at Picatinny Arsenal 13
DR. G. C. HALE.

Organization and Administration of Development Work at Picatinny Arsenal 19
MAJ. H. H. ZORNIG, Ord. Dept., U. S. A.

Robert S. Brookings Addresses Army Industrial College Graduates 22

Pyrotechnics 23
CAPT. IRA A. CRUMP, Ord. Dept., U. S. A.

Fuzes 27
H. M. BRAYTON.

Army and Navy Club of Philadelphia 32

Safety in Explosives Plants 33
H. S. DECK.

Filling Armor-Piercing Projectiles With High Explosive Bursting Charges—A Foreword 39
HUDSON MAXIM.

Loading Ammunition at Picatinny Arsenal 40
CAPT. JOHN P. HARRIS, Ord. Dept., U. S. A.

PAGE

Col. Frank A. Scott, Ord. Res., Chief, Cleveland Ordnance District, Honored 48

High Explosives 49
C. J. BAIN.

The Relation of Picatinny Arsenal to Field Service 53
FRED OLSEN.

Class of '26, U. S. M. A., Visits Frankford Arsenal and Aberdeen Proving Ground 58
CADET WILLIAM E. HOUSE, U. S. M. A., '26.

Editorial 60
Picatinny Arsenal, 1880-1926—Complete Rounds—Reserve Officers.

Historical 62
Kunckel's Discovery of Fulminate.

Theater of Operations 64
Organization—War Planning as Applied to Ordnance Units.

Professional 68
The Explosive Properties of the Silver Salts of Some of the Nitro-Aromatic Compounds and Silver Oxalate.

Personnel 70
Commendations for Heroic Conduct—Meeting of Boston Post, A. O. A.—New York Post, A. O. A., Elects Officers—Meeting of Ordnance Reserve Officers Assigned to Buffalo District and Watervliet Arsenal—Reserve Officers Entertain—Cleveland Ordnance Reserve Officers Visit Erie Proving Ground—Recently Reappointed Ordnance Reserve Officers—Recently Commissioned Ordnance Reserve Officers—Recently Assigned Ordnance Reserve Officers—National Guardsmen at Citizens' Military Training Camps.

Ordnance News in Pictures 75

Who's Who in This Issue 76

Patents 77
Patent Rights of Government Employees.

Books 80

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¶ The time has passed when military preparedness can be considered merely a question of trained man-power. The development of the methods of modern warfare must be supplemented with a knowledge of the methods of production of modern implements of war. Experience has shown that men can be mobilized and reasonably trained in from three to six months if the necessary ordnance is available. Industry today requires for mobilization and mass production of war material a period of from nine to eighteen months. The mobilization of the munitions industries is the Ordnance problem.

¶ The industries of America know perfectly well how to house, to feed, to clothe, to transport men called to the colors. The civilian professions of medicine, surgery, dentistry, law and banking similarly develop great reservoirs of readily available personnel for preserving and restoring the health of an expanded army, for administering its judicial system, and for paying it.

¶ But, a man, even a man of military training—well fed, well housed, well clothed, well paid, is not a soldier until he receives the tools of his trade—ORDNANCE.

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The Eighth Annual Meeting

of the

Army Ordnance Association

will be held at

The Aberdeen Proving Ground, Maryland

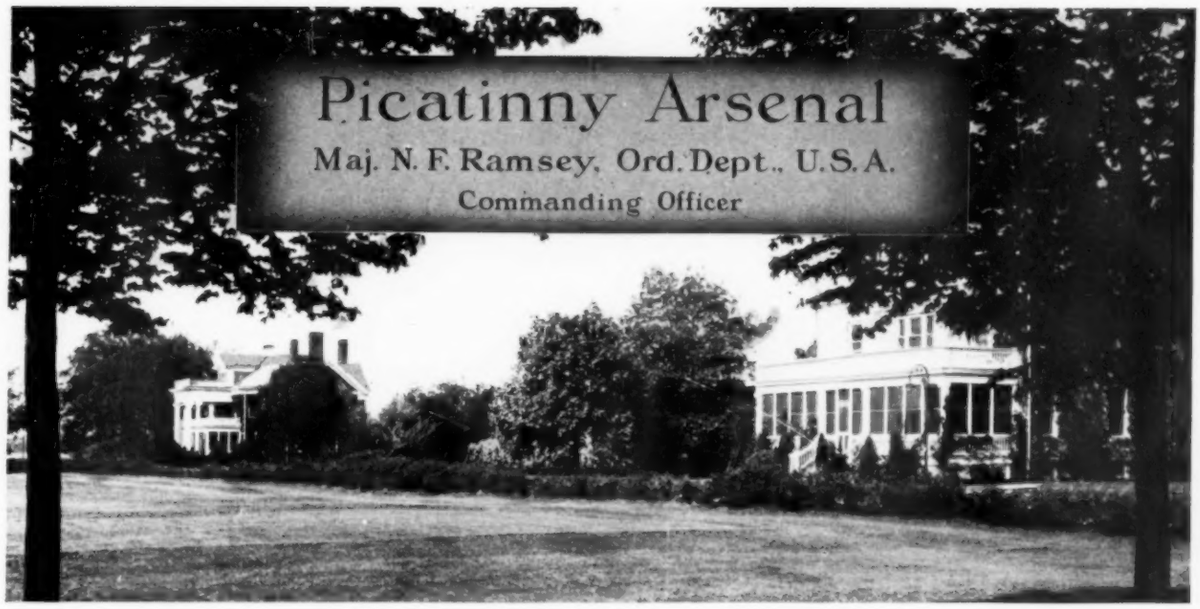
Friday, October 8, 1926

We are privileged to have with us as participating guests:
The National Association of Manufacturers
The Reserve Officers' Association of the United States
The American Society for Steel Treating
and
The National Industrial Conference Board

Further announcement as to the program of events, special trains, reduced railroad rates and meals will be published in the September-October issue of ARMY ORDNANCE.

Members of the Army Ordnance Association and guests will receive personal invitations and other data in due course.

Reserve This Date
October 8, 1926

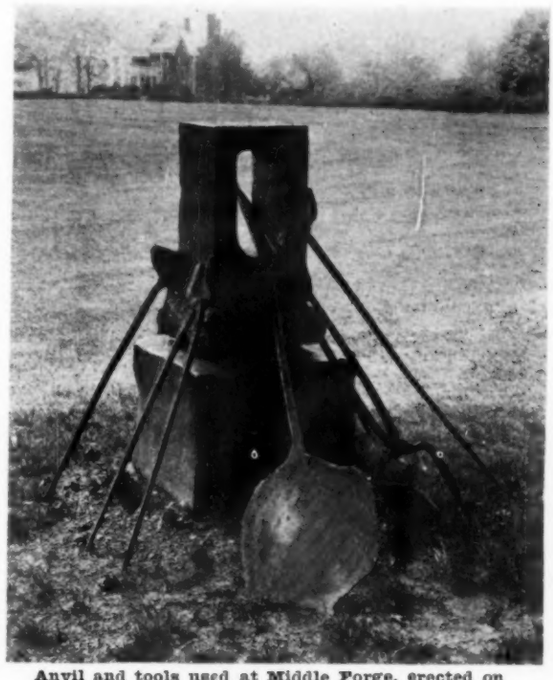


Parade Ground and Officers' Quarters, Picatinny Arsenal.

WHENEVER Picatinny Arsenal is mentioned this question almost invariably follows: "Where is Picatinny? I've never heard of it before." On being told that it is in New Jersey near Dover, the questioner will in all probability say—"But I thought Dover was in Delaware." For their benefit and for those who have formed their ideas of New Jersey while looking from a car window, a map showing the location of Picatinny Arsenal with relation to New York City, Philadelphia, Trenton, Easton and West Point is shown with this article. Dover is in the Highlands of New Jersey, midway between the Hudson and Delaware Rivers, and is 39 miles from New York City on the main line of the Delaware, Lackawanna and Western Railroad.

The Picatinny Arsenal reservation is 5 miles north of Dover, with a hard surface road connecting it with the excellent New Jersey State highway system. It is 710 feet above sea level. The reservation contains 1,615 acres, and lies in the valley of Green Pond Brook, a tributary of Rockaway River. The boundaries are irregular, but roughly the reservation is about one mile wide at its maximum width and about 3½ miles long. The country roundabout is rough and mountainous, and sparsely inhabited. The Arsenal takes its name from Picatinny Peak, a mountain which rises abruptly from the general level of the valley, and at the foot of which lies a beautiful and picturesque lake about a mile long. The name "Picatinny," like many others in the vicinity, is of Indian origin.

It is probable that the first settlers came to this community because of the presence of iron ore in great abundance, because of the forests which were readily convertible into charcoal, and also for the water power available for the operation of the forges. In 1749, Jonathan Osborne built a forge, "Middle Forge," at the foot of Picatinny Lake, and it was continued in operation until a few years before the land became Government property. The anvil and some of the tools used at this old forge may be seen on the lawn in front of the officers' quarters.



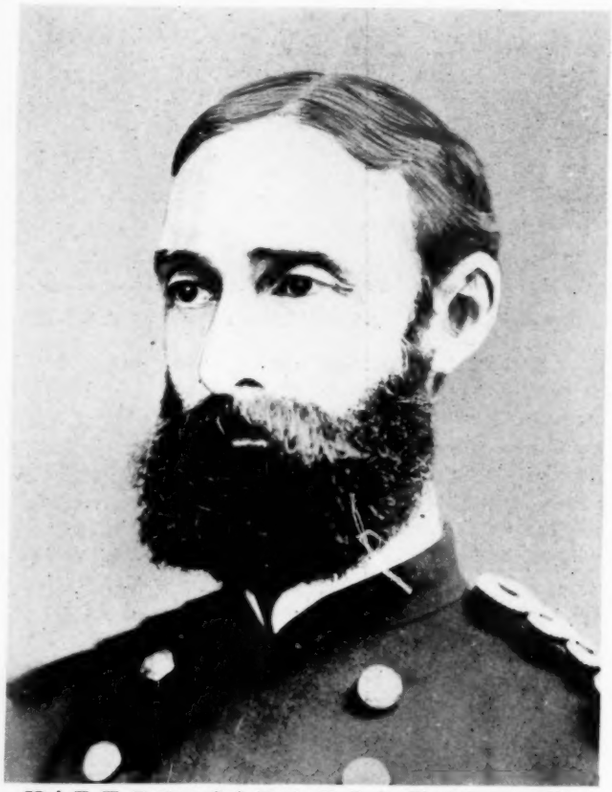
Anvil and tools used at Middle Forge, erected on Picatinny Lake in 1749 by Jonathan Osborne.

It is hearsay amongst the older inhabitants of the countryside that some of the ordnance for Washington's Army was forged at Middle Forge. As for the truth of this I can find no proof, but there is an old Hessian cemetery less than a mile away. It seems quite possible, therefore, that Washington used his Hessian prisoners to operate the mines and forges in this vicinity.

In 1879, Congress made an appropriation for the purchase of a site for a Powder Depot and for starting the erection of suitable buildings. Major F. H. Parker, Ord. Dept., U. S. A., was designated to inspect tracts of land which might be suitable for the purpose. He examined

nine sites within 100 miles of New York City. The present location was finally selected by the Board, and its recommendation was approved by the War Department. The five tracts of land originally purchased consisted of 1,866.12 acres, which were bought for $62,750.00. Later a strip of land 50 feet wide and 7,412 feet long was purchased for use as a roadway connecting the Arsenal with the Dover-Sparta road. There has been no further purchase of land, except in 1918 when the adjacent Robinson farm was acquired to round out existing boundaries. In 1891, 315 acres of the reservation were transferred to the Navy Department for storage purposes. This is now known as the Lake Denmark Naval Ammunition Depot.

On September 6, 1880, the Secretary of War designated the reservation as the "Powder Depot," and four days later issued an order calling it "Picatinny Powder Depot." In June, 1883, the name was changed to the "U. S. Powder Depot," and this name was retained until 1907 when the Arsenal received its present designation "Picatinny Arsenal."



Maj. F. H. Parker, Ord. Dept., U. S. A., First Commanding Officer, Picatinny Arsenal.

Major Parker, the junior officer on the Board which had selected the site, was assigned as the first Commanding Officer, and under his direction the necessary construction work was begun. The first building erected, now known as Building No. 20, was a magazine 200 by 50 feet with a 6-foot basement, and was built at a cost of $51,700.00. This building is in excellent condition at the present time after 45 years of service, a testimonial to the design and the quality of workmanship and materials which entered into it. Four other magazines, now known as Buildings Nos. 43, 38, 30 and 27, were subsequently erected in that chronological order from the same plans, except that basements were omitted.

The only other buildings erected during this period were the Stables, Building No. 5, Officer's Quarters No. 2, and Office (now Quarters No. 1), in addition to the necessary service buildings.

The first phase of the development of the Arsenal extended to the year 1902, and the history of the Depot was one of gradual construction, with the ultimate idea of an establishment for the storage of powder. About this time the need was felt for the storage of a war reserve of sodium nitrate, of armor-piercing projectiles, and of high explosives, and the second phase of the development of Picatinny began. Six projectile sheds and some nitrate buildings were erected. A year later a temporary plant was installed for filling projectiles with maximite, and several thousand armor-piercing projectiles were filled with this explosive. Later explosive D was adopted as the shell filler, and in 1906 and 1907 the maximite-loaded shell were unloaded and some shell were loaded with explosive D. About this same time, machinery was installed for modifying the projectiles to make them satisfactory for use with the new explosive and to increase their efficiency.

The third phase of the Arsenal's development began with the appropriation in 1906 of $165,000.00 for the erection and equipment of a powder factory. The selection of Picatinny Arsenal, recommended to the Chief of Ordnance by a Board of Officers, was approved by the Secretary of War. The work of preparing the plans was originally assigned to Major B. W. Dunn, Ord. Dept., U. S. A., who took command of the Powder Depot. Shortly after he assumed command, however, he was engaged by the American Railway Association to organize the Bureau of Explosives. For the second time in the history of the Arsenal, it fell to the lot of the junior member of the Board which selected the Arsenal for a particular purpose to carry out the plans for its development. Major O. C. Horney, Ord. Dept., U. S. A., assumed command of the Arsenal on June 10, 1907, and during the eight years he was in command the original capacity of the powder factory, which he built on the rocks and in a wilderness, was increased from 3,000 pounds to 9,000 pounds of cannon powder per 24-hour day. Also, machinery for the manufacture of 300 pounds of caliber .30 powder per day was installed. A plant for the manufacture of explosive D was built, and a school of instruction in Chemistry, Explosives and Interior Ballistics was established. The investment in the powder factory and in the training of officers on powders and explosives was repaid many times during the World War when one considers the tremendous responsibilities borne by General Horney, and such officers as Cols. C. T. Harris, Jr., D. C. Seagrave, J. H. Burns and F. M. Miles, and how much more difficult and trying such positions would have been without the training and experience gained at Picatinny.

Shortly prior to the entry of the United States into the World War the production of smokeless powder was increased, but, with the tremendous capacities developed by private manufacturers, the production of the Arsenal was

Commanding Officer's Quarters, Picatinny Arsenal.

only a small share of the necessary requirements. In May and June, 1917, it became apparent that considerable storage space would be required by the Ordnance Department for the storage of powder, explosives, and metal components, and Picatinny was selected as the site for a storage project. Under a contract with Stone and Webster fifty-four buildings were constructed for this purpose. Railroad tracks, roads, garage, round house, an addition to main office, power house, and other utilities for the storage project utilized accessible areas to the limit.

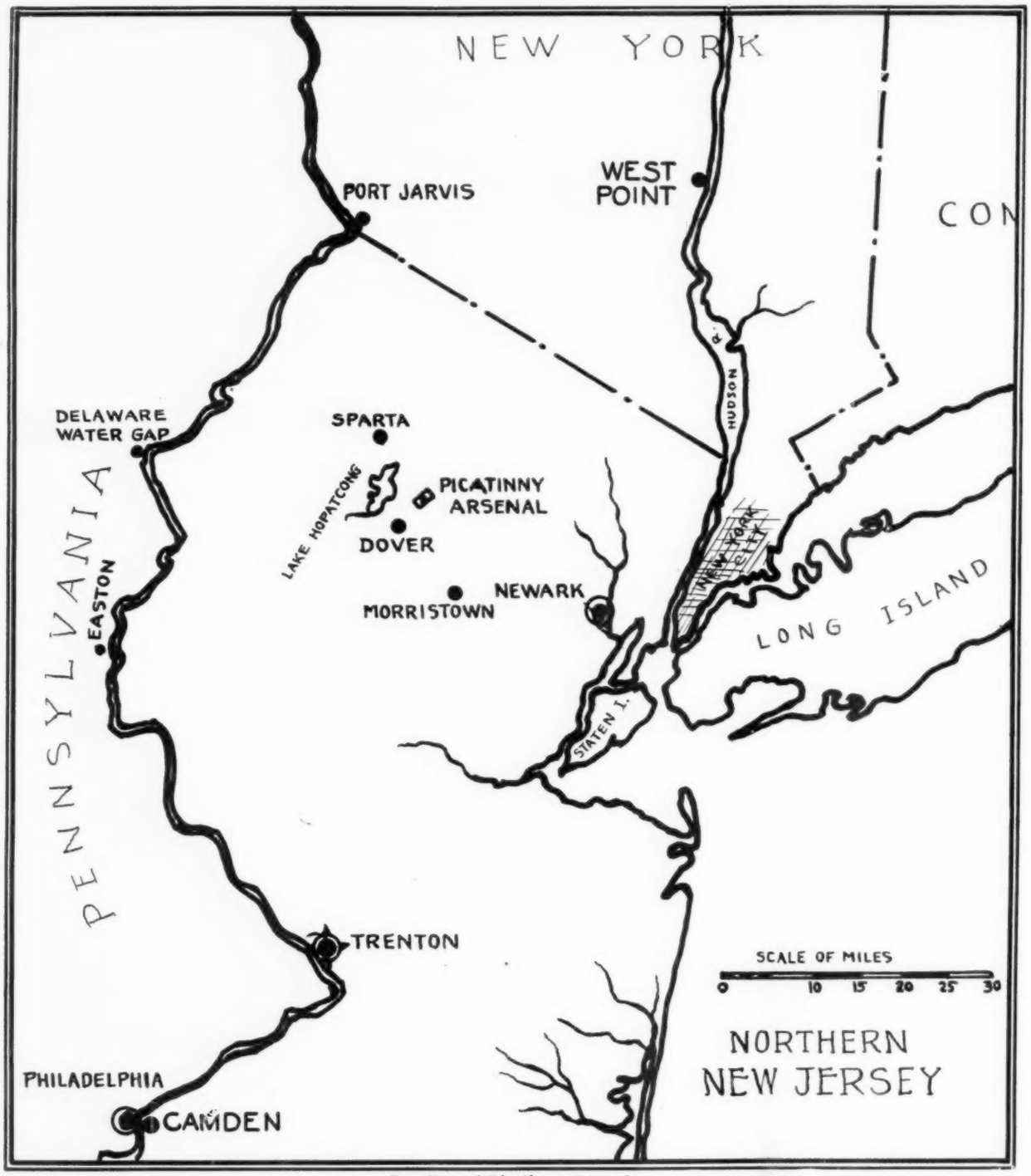
After the Armistice in November, 1918, when there were vast quantities of smokeless powder on hand, the manu- was stopped and Picatinny entered into its fourth phase of development, a Field Service Depot. This status existed for about a year, and then approval was finally obtained for the establishment of an experimental ammunition plant at Picatinny Arsenal. Thus the Arsenal entered into the fifth and present phase of its development.

About the middle of August, 1919, active work was begun on the establishment of a small experimental plant for the design and development of artillery ammunition. This project involved the establishment of shops for the experimental manufacture of metal components, renovation of the existing powder factory, and installation of suitable experimental plants for the study of raw materials, high explosives, military pyrotechnics, and trench warfare materials.

As far as practicable, the plants and shops were designed to fit existing structures and to utilize machinery

Officer's Quarters, Picatinny Arsenal.

and equipment remaining on hand at the close of the war. The power house was redesigned, equipped with a new boiler plant and an electrical generating system. New electric and steam transmission lines, and new sewer, fire



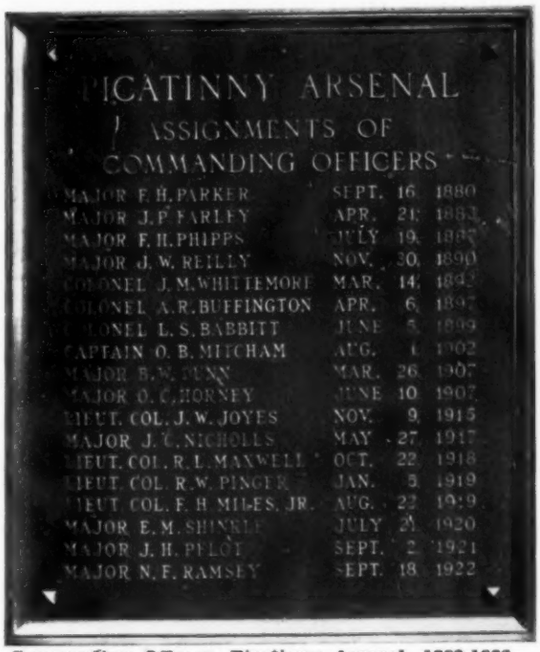
Location of Picatinny Arsenal

and water systems, were designed and built. It was necessary to modify approximately fifty buildings, some of the work being done by the Arsenal forces but the greater part under contract. The technical personnel for the development of metal components was obtained from Frankford Arsenal in 1921, while the personnel for the loading work was drawn from the vicinity or by the employment of men who had had loading experience during the World War. An organization has been built up gradually which is now able to carry out its mission of experimental and development work, and to load the various components of artillery ammunition, pyrotechnics, and trench warfare material.

At present there are 11 officers and 4 enlisted men stationed at the Arsenal, and the employees number 530. Large quantities of components of artillery ammunition are held in war reserve, and are drawn on as required for

loading and assembling as directed by the Chief of Ordnance.

While the research and investigative work is carried on with a view to its adaptation to service material as occasion may warrant, preparedness for war is not lost sight of, and an endeavor is being made to assemble an organization which will form a technical center so far as ammunition is concerned. It is conceived that there would be referred to such an organization in time of war the research and development work similar to that carried on in peace time, except that it would have to be done in the greatest possible haste. It is also conceived that there should be referred to such an organization the larger questions as to whether certain materials not quite in accordance with the drawings or specifications should be accepted; in other words, the technical organization would determine whether the deficiencies were serious enough to cause the rejection of the material.


PICATINNY ARSENAL
ASSIGNMENTS OF
COMMANDING OFFICERS
MAJOR F. H. PARKER SEPT. 16 1880
MAJOR J. P. FARLEY APR. 21 1883
MAJOR F. H. PHIPPS JULY 19 1885
MAJOR J. W. REILLY NOV. 30 1890
COLONEL J. M. WHITTEMORE MAR. 14 1894
COLONEL A. R. BUFFINGTON APR. 6 1897
COLONEL L. S. BABBITT JUNE 5 1899
CAPTAIN O. B. MITCHAM AUG. 1 1902
MAJOR B. W. DUNN MAR. 26 1907
MAJOR O. C. HORNEY JUNE 10 1907
LIEUT. COL. J. W. JOYES NOV. 9 1915
MAJOR J. C. NICHOLLS MAY 27 1917
LIEUT. COL. R. L. MAXWELL OCT. 22 1918
LIEUT. COL. R. W. PINGER JAN. 5 1919
LIEUT. COL. F. H. MILES, JR. AUG. 22 1919
MAJOR E. M. SHINKLE JULY 21 1920
MAJOR J. H. PELOT SEPT. 2 1921
MAJOR N. F. RAMSEY SEPT. 18 1922
Commanding Officers, Picatinny Arsenal, 1880-1926.

In case of an emergency, the productive capacity of the Arsenal for smokeless powder and for the loading of artillery ammunition would be relatively small when compared to the tremendous plants which would have to be brought into existence to meet the war-time demand, but in the first line of industrial defense, Picatinny Arsenal holds a prominent place. The material it produces will not only serve to meet urgent requirements of the early stages of a war, but the Arsenal has the experience and the necessary equipment installed which could not be acquired readily by a commercial concern. It is, therefore, in a position to instruct and assist industry in what is required of it in an emergency, and at the same time train the ammunition inspection forces so that they will be able to perform their duties capably and with dispatch.

Pittsburgh Ordnance Officials Witness High Explosive Shell Test

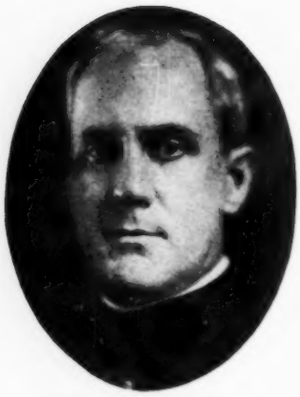
A PARTY of Ordnance officials, at the invitation of Mr. Ralph M. Dravo, Chief of the Pittsburgh Ordnance District, visited Aberdeen Proving Ground, May 11, 1926, to witness tests of 75-mm. Mark IV high explosive shell made from seamless tubing. Previous to the arrival of the party fragmentation tests of these shells had been conducted and an opportunity was afforded the visitors to compare the number and size of the fragments obtained from the seamless tube shell with the number and size of fragments from standard shell. More fragments were obtained from seamless tube than from the standard shell.

Later in the day fifty shells were fired from the 75-mm. gun, burst and range being observed by the entire party from dugouts down the range. The shells fired in this test were developed by the National Tube Company in cooperation with the Pittsburgh District Ordnance Office and the Office of the Chief of Ordnance. The projectiles were manufactured from steel complying with the standard specifications for shell steel, and hot rolled seamless steel tubing was produced from this material. The shells were sent to Frankford Arsenal for machining and to Picatinny Arsenal for loading and assembling. From the results obtained during this test the prospect is very promising for the complete success of the new method of manufacturing shells.

Those who witnessed the tests, in addition to Mr. Dravo, were: Taylor Allderdice, President, National Tube Company; Col. Harley B. Ferguson, U. S. A., Office of the Assistant Secretary of War; Lt. Col. G. P. McNiff, Ord. Res., Vice-Pres., National Tube Company, and Chief, Ammunition Division, Pittsburgh Ordnance District; Lt. Col. Wm. Hogg, Ord. Res., Asst. to Vice-Pres., National Tube Company, and Chief, Contract Division, Pittsburgh Ordnance District; Maj. G. M. Sixsmith, Ord. Res., Superintendent of Transportation, Pennsylvania Railroad Company, and Chief of Transportation Division, Pittsburgh Ordnance District; Maj. Wm. B. Hardigg, Ord. Dept., U. S. A., Chief of the Ammunition Division, Office of the Chief of Ordnance; Maj. T. J. Smith, Ord. Dept., U. S. A., Manufacturing Service, Office of the Chief of Ordnance; Capt. Fred A. McMahon, Ord. Dept., U. S. A., Executive Assistant, Pittsburgh Ordnance District; Capt. H. F. Safford, Ord. Dept., U. S. A., Ammunition Division, Office of the Chief of Ordnance; and Arthur Adelman, Technical Staff, Office of the Chief of Ordnance.

Military Staff
Picatinny Arsenal
1926

Maj. H. H. Zornig
Chief, Technical Division



Maj. N. F. Ramsey
Commanding Officer

Maj. F. H. Miles, Jr.
Chief of Operations

Maj. C. G. Young
Technical Division

Capt. I. A. Crump
Technical Division

Capt. J. P. Harris
Loading Department

Capt. J. G. Holmes
Explosives Department

Capt. C. S. Reed
Technical Division

Lieut. W. L. McPherson
Loading Department

Capt. L. A. Luke
Research Physicist

Lieut G. W. Bott, Jr.
Explosives Department

Tech. Sgt. C. J. Vogt
Outside Safety Engineer

Civilian Staff
Picatinny Arsenal
1926

H. S. Deck
Plant Engineering Division

E. W. Jenkins
Metal Components Department

W. J. Richards
Service Department

C. J. Bain
Technical Division

G. C. Hale
Chief Chemist

H. M. Brayton
Technical Division

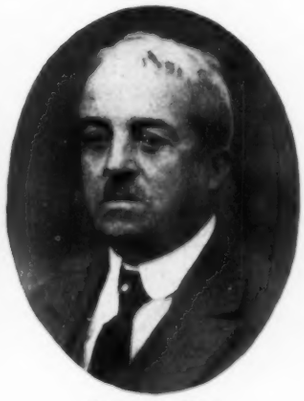
R. L. Clothier
Stores Department

R. E. Stickle
Chief Clerk

Fred Olsen
Technical Division

J. P. McCormick
Loading Department

A. H. Dill
Chief Inspector



Samuel Wiley
Technical Division

E. Williams
Planning Division

Among the Pioneers at Picatinny Arsenal Powder Factory

BRIG. GEN. JOHN W. JOYES,
Ord. Dept., U. S. A.

Commanding Officer, Picatinny Arsenal, 1915-1917. General Joyes is now Assistant Chief of Ordnance and Chief of Field Service, Ordnance Department.

COL. WM. H. TSCHAPPAT,
Ord. Dept., U. S. A.

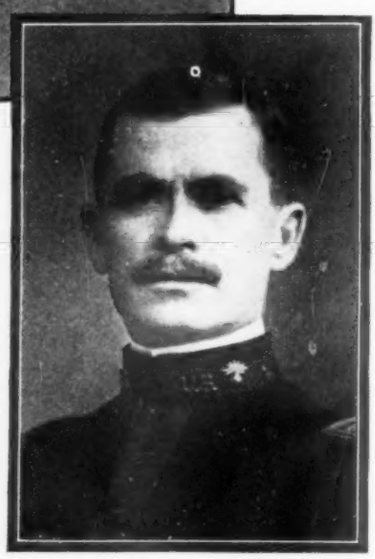
in charge Chemical Laboratory, Picatinny Arsenal, 1907 - 1912. Colonel Tschappat is now Chief of the Technical Staff, Office of the Chief of Ordnance.

COL. ODUS C. HORNEY,
Ord. Dept., U. S. A.

Commanding Officer, Picatinny Arsenal, 1907 - 1915. Colonel Horney is now Commanding Officer of Frankford Arsenal, Philadelphia, Pa.

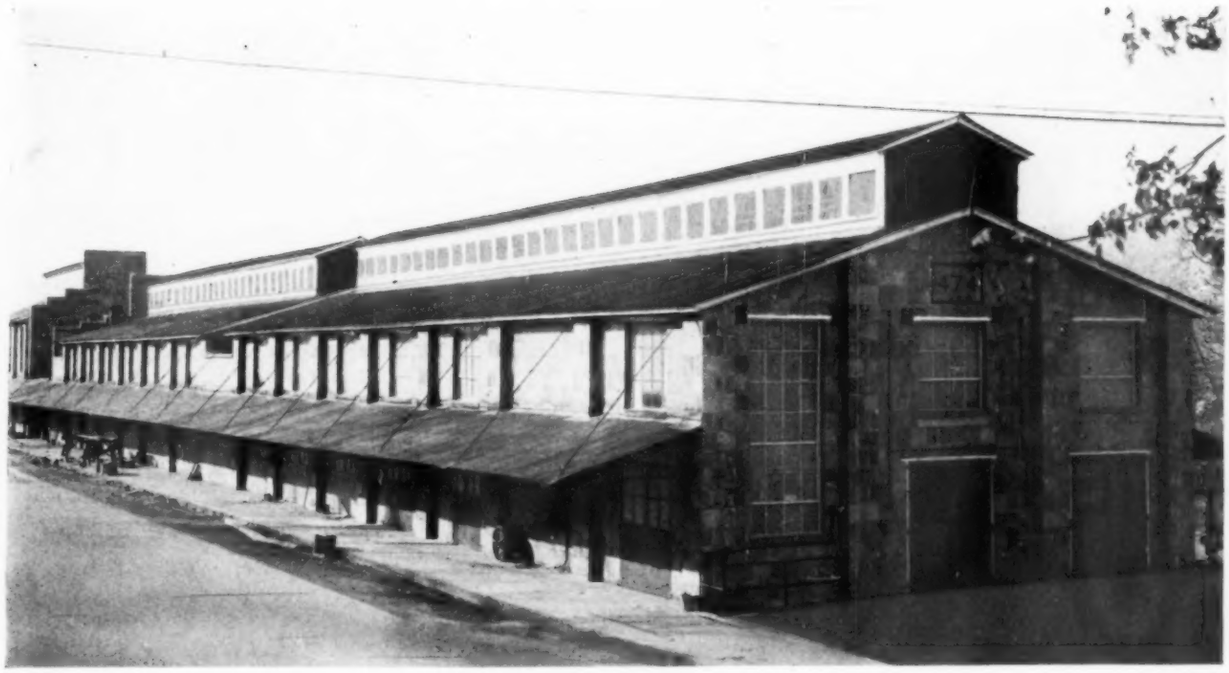
COL. J. C. NICHOLLS
Ord. Dept., U. S. A
Retired.

Commanding Officer, Picatinny Arsenal, 1917 - 1918. Colonel Nicholls is now Commandant, Military Department, Cornell University, Ithaca, N. Y.



COL. B. W. DUNN
Ord. Dept., U. S. A.
Retired.

Commanding Officer, Picatinny Arsenal, 1907. Colonel Dunn is now Chief of the Bureau of Explosives, American Railway Association, New York, N. Y.



The Powder Factory, Picatinny Arsenal.

The Picatinny Arsenal Powder Factory

Maj. F. H. Miles, Jr., Ord. Dept. U. S. A.

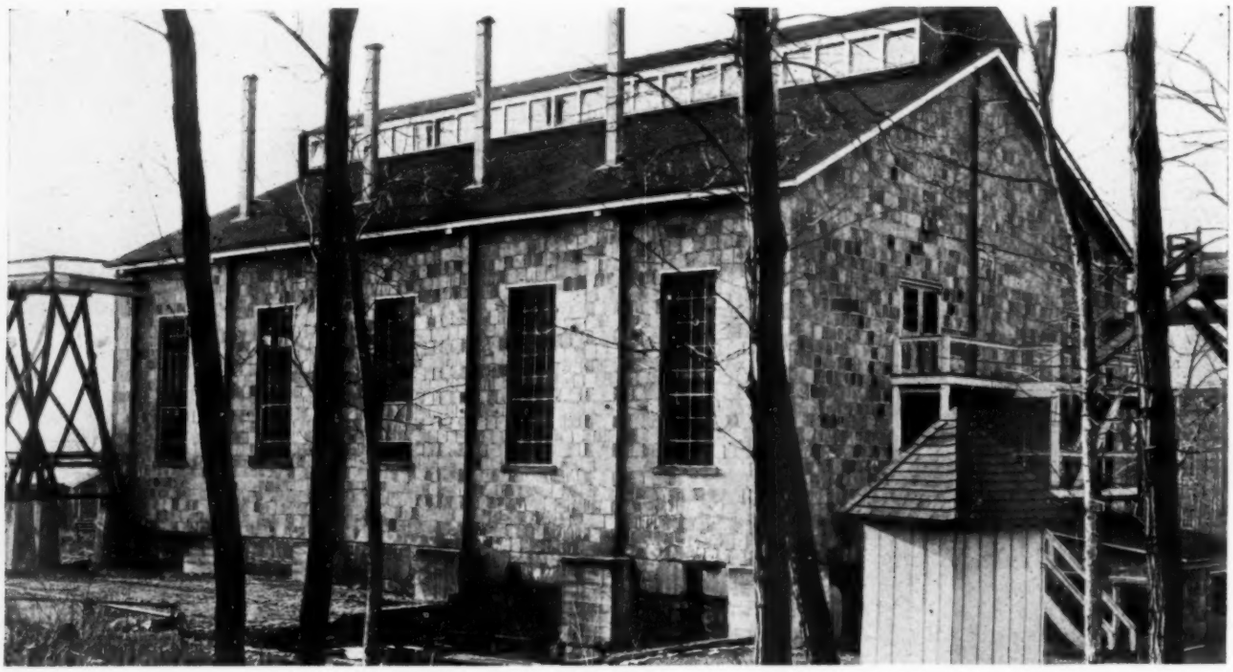
MANY people including some active Ordnance officers still think of *powder* when Picatinny Arsenal is mentioned. This is natural since the first and only Army powder factory was established there in 1907, and has been operated more or less continuously since that time. Now, however, the powder factory is but a small part of the general ammunition activities which are carried out at the Arsenal, and it is possible that the importance of the factory as an Ordnance activity is not appreciated. There is no doubt that the factory has been the agency through which the Army has gained the larger part of the technical powder information which it now has. In fact, what the Army knows about technical explosives is directly attributable to the establishment of the powder factory and its control laboratory.

The value of a technical laboratory is well emphasized by the experiences of the dean of Army explosives men, Col. Beverly W. Dunn, Ord. Dept., U. S. A., retired, who in the early days was charged with the development of a suitable high explosive for armor-piercing projectiles. He argued that if he had a laboratory where he could make a few simple physical and chemical tests on the many known explosive compounds, he could probably narrow the field of available explosives without resort to expensive gun tests. After many arguments and much disheartening work, he finally prevailed upon those in authority to build him such a laboratory at Sandy Hook Proving Ground. In a few months, he had eliminated, inexpensively, most of the suggested explosives, and proposed for exhaustive test the explosive which has been the standard armor-piercing projectile explosive ever since. It is a fitting tribute to his sagacity that this explosive should have been named "Explosive D" in his honor.

It was Colonel Dunn who was detailed to build the powder factory at Picatinny. The plans were made by him and the factory construction was started under his command. Before it was completed, he was retired but not without leaving on the work the impress of his splendid mind.

He was succeeded by Gen. Odus C. Horney, Ord. Dept., U. S. A., then Major Horney, who carried the factory to completion, and made a reality of powder making for the Army. The original appropriation for the powder factory was something over seventy-seven thousand dollars ($77,000.00), and that such a feat could have been performed for so little money was indeed a tribute to these two founders of the work.

Another fortunate feature of the early work was the role given the chemical laboratory, which was started not



The Beater House, Picatinny Arsenal Powder Factory.

only with the idea that it should do plant control work, but that it should also provide facilities for research and development work. To Col. W. H. Tschappat, Ord. Dept., U. S. A., then Major Tschappat, fell the burden of starting this important work. Most of us have heard of Tschappat's *Ballistics* but few of us know that this work was started at Picatinny. There is abundant evidence at Picatinny that Colonel Tschappat's time was well spent.

From time to time, improvements in the factory were made, the laboratory was housed in an up-to-date building, and by 1916, the art of powder making was well established in its essentials.

The powder factory was established for the manufacture of powders with the nitro-cotton base, and an interesting feature of the manufacture of nitro-cotton at Picatinny was the nitration, known as the Thompson displacement process. In this process, as in all others, the dry cotton was immersed in a nitrator in a mixture of nitric and sulphuric acids. The unique feature of this method was the means of separating the cotton from the acid after nitration. This was performed by running cold water on top of the contents of the nitrator and drawing off the acid from the bottom of the nitrator at the same rate as that at which the water was added. In this way the acid was displaced by the water, hence the name, displacement process. While this method of nitration was economical in the use of acid, there were certain drawbacks to it which caused it to be replaced by the more productive DuPont method of nitration in which the acid is separated in centrifugal wringers.

The Poaching House, Picatinny Arsenal Powder Factory.

Another feature of the pre-Armistice factory was the cannon blender proposed and designed by Col. J. C. Nicholls, Ord. Dept., U. S. A., who commanded the Arsenal during the greater part of the World War. A blender takes the dried powder from the dry houses where it has been placed as grained with no attempt at mixing various days' runs, and thoroughly mixes or blends the powder. Prior to Colonel Nicholls' design, the blender was a high tower in which the blending was accomplished by hoisting

The Smokeless Powder Blender, Picatinny Arsenal.

the powder to the top of the blender and dropping it through a succession of inverted pyramidal bins to the ground floor and then repeating the operation until a proper blend was attained. The operation of these blenders required that a crew of men be stationed on the top floor of the blender while the upper bin was being charged. Quite a number of blenders have burned, sometimes with a considerable loss of life. Colonel Nicholls' blender consisted of two towers with one inverted pyramidal bin each. Belt conveyors were arranged so that the bin of one tower was charged from the ground floor of the other by means of belt conveyors. In this way no workmen are required on the top floor of the blender towers and the blender is much safer to operate.

Prior to the war all sizes of powder from caliber .30 to 16-inch were made in the Army powder factory and the production varied from 5,000 to 7,000 pounds a working day. It is interesting to note at this point that since the war except for the time when the factory was being rebuilt an average of less than 750 pounds a working day has been produced. At the present time the amount of powder made is so small that reasonable costs cannot be reached. Of course, since the war, with every emphasis on economy and rather large stocks of powder left over from the war, a reasonable production has not been possible. However, with the war powders fast coming to the end of their stability life, and with the Congress recognizing the wisdom of maintaining these reserve stocks, it is to be hoped that the factory may again be placed on a production basis. To make sure that the Ordnance Department is at all times familiar with the technique of powder manufacture and that reasonable costs are maintained, the Army powder factory should make a sufficient amount of each kind of powder needed.

It is as true today as it ever was that what we can afford to do in our research and investigational work largely depends upon the stabilizing effect of and the overhead which is permitted by the operation of the powder factory on a production scale.

During the war, the explosives program was always well ahead of the other components of ammunition. So far

Hoisting Belt in Smokeless Powder Blender, Picatinny Arsenal.

as production was concerned, the country owes much to the efficiency of the DuPont, Hercules, Aetna and Atlas Powder Companies. But even in production matters the effect of Picatinny was felt, for while its own production was insignificant, personnel trained at Picatinny made an excellent showing elsewhere. However, perhaps the greatest return to the country from the personnel trained at Picatinny was from the commissioned officers of the Ordnance Department upon whom fell the burden of preparing for the tremendous production which was to follow. Had the initial administration of the explosives supply been in untrained hands, no end of confusion probably would have existed. If no other return on the investment made at Picatinny had ever come from it, the procurement of explosives in proper quantity and quality during the World War at less tha pre-war costs would have justified hundreds of times over the total expenditure made at Picatinny Arsenal prior to the war. If at any time the value of Picatinny in the preparedness scheme is being considered, its value as a training center must not be overlooked.

Some of us can still remember the sensation of achievement which accompanied the substitution of smokeless powder for the time honored black powder. More of an achievement however was the discovery that the rate of combustion and consequently the evolution of the gas of the powder could be controlled in such a way as to maintain a propulsive effort behind the projectile without exceeding the strength of the gun. This principle had been applied to black powder and to its brother, brown powder, before the introduction of smokeless powder. Black and brown powders gave off copious amounts of smoke; so much so that the introduction of smokeless powders in the last decade of the nineteenth century was hailed as a momentous advance in powder design. Giving off almost no smoke, and permitting control of the rate of combustion to a degree unheard of with black and brown powders, the new powder was indeed an advance. However, smokeless powders, usually with a base of nitro-cotton or one of nitro-cotton and nitro-glycerin, give off a vivid flash upon discharge in a gun, and for certain uses prove quite as objectionable from this standpoint as the older powders had from the smoke nuisance. Both smoke and flash greatly increase the visibility of the gun position.

The entire World War was fought with smokeless but not flashless powder. However, experience in the war made the development of flashless powders appear very desirable. Also, except for fixed ammunition where non-hygroscopicity is not of such great importance, the tendency of the service powder to absorb moisture was recognized as a definite fault. Some work had been done on flashless powders for cannon before the war but by far the greater part of research and development work on powder prior to the war had been in the direction of improving the quality and reducing the cost of the service nitrocellulose smokeless powder. For small arms, the DuPont Company brought out their Improved Military Rifle powder before the war, and variations of it are now proving satisfactory in the caliber .30 and .50 weapons. None of this improved small arms powder has been manufactured at Picatinny Arsenal however.

With the exception of the infantry armament, therefore, there had been little progress prior to 1919 in the direction of substituting for the service nitrocellulose powder, powders which would overcome flash and hygroscopicity. Such a program was launched in 1919, and F. N. H. (flashless, non-hygroscopic) smokeless powders were demanded.

In furtherance of the campaign for better powders, the chemical laboratory at Picatinny is solving the intimate problems of powder manufacture in a truly scientific spirit which promises much for the art. Cotton purification and structural colloids as attacked by the laboratory are indicating lines of improvement that cannot be denied their place. Powder drying is being studied in the light of recent scientific progress, by the Arsenal engineering staff and many other scientific applications to the art are being investigated in a thorough-going manner. The laboratory may truly be said to be becoming more and more indispensable.

The quest for better powders has been entered into most industriously by the DuPont Company and by Picatinny Arsenal. Not much was known at the outset as to how flashlessness was to be obtained. There were theories about reducing the temperature of the gases so that upon discharge from the gun the gases would be so cool that they would not burn when coming into contact with the oxygen of the air, but the conditions that had to be met to secure the result were unknown. Working along quite different lines both organizations have produced results, and it is believed that the fundamental conditions which lead to flashlessness are no longer guess work. Non-hygroscopicity has not been a very difficult problem. The early flashless powders showed an increase in smoke over the powders they were to replace, but the latest powders are quite satisfactory from this standpoint. Another sidelight which may be interesting is the apparent relation between flashlessness and noiselessness. As the powders become more flashless, they become more noiseless, and it is perhaps possible that we shall ultimately have noiseless, flashless, smokeless powders. Picture the uncanny, unorthodox state that warfare will be in when the guns, besides being properly camouflaged, do not flash and smoke, and are noiseless. And who shall say how many years of development and periods of impetus coincident with war shall pass before such a product is obtained.

Just how flashless, smokeless, and noiseless are these powders now,—may be asked. The flash is a dull red glow visible under the best of conditions for only three or four hundred yards, and entirely invisible with a muzzle below the military crest of a hill. The smoke is that given off by the black powder igniting charge and when a smokeless igniter is produced practical smokelessness will be had. The noise has been reduced to such an extent that the sound ranging equipment developed during the war is quite ineffective at least for the smaller guns and howitzers.

The future of the powder factory at Picatinny will demand no end of constructive effort, and it is hoped that the progressive spirit which now animates those in the work may not cease, and that Picatinny will continue as in the past to bring to mind *powder* as one of its achievements in the problem of "preparedness against war."

Main Laboratory for Chemical Research, Picatinny Arsenal.

Research Activities at Picatinny Arsenal

Dr. G. C. Hale

ART in industry is rapidly giving way to science. For many years the fields of pure science were explored only by those whose temperament led them into the research laboratories of universities or whose inventive turn of mind urged them, supplementary to other interests, to a scientific study of some special phase of nature's varied phenomena. From such sources the fundamentals of each science have been gradually evolved and as they have become more and more a matter of common knowledge have been applied more or less haltingly to practical purposes. The great industrial and commercial activity of recent years was made possible only by the laborious but inspiring efforts of such pioneers in science as Faraday, Avogadro, Helmholtz, Kekule and Pasteur who sought to establish the principles and laws underlying the once commonly accepted mysteries of nature.

Industry as a whole has been little concerned in the past with the researches of such men as those just mentioned, for it failed to realize the extent to which its status was dependent upon the fundamental conceptions of science as established by their work. Many industrial processes were thus carried out profitably by rule of thumb methods, the guiding force having little or no acquaintance with the basic principles involved. But as scientific research gradually brought forth more and more data which were directly applicable to many commercial processes, the more enterprising in the industrial field sought to make use of such data in extending their acivities; research laboratories of a more or less pretentious nature began to appear as a part of the industrial layout and soon became a beacon in the storms that so often arose from inefficient processes and defective products. Germany as a country was, without doubt, the first to correlate extensively scientific research with industrial problems, and at the outbreak of the World War was far in advance of any other country in the extent to which her industries were guided by the established principles of science. This enabled her to effect an orderly transition from peace time activities to those made suddenly necessary by military demands. Many of the other countries engaged in the conflict soon realized their weakness in this respect; they hurriedly assembled their technically trained men, organized research and development stations and began with feverish haste to collect the fundamental information necessary to enable the industries to meet the new demands upon them.

This quickening of research for the purpose of immediate application during the war has had a profound influence on the relations between science and industry since the war. Books are being written, lecturers are earnestly pleading, and events are unfolding, all to the effect that the future salvation of industry is in research. Industry is being rapidly revolutionized by the researches of the chemist, the physicist and others of similar habits of thought, many of the older practices either being rendered obsolete or allowed to exist by such a narrow margin that

they are resting uneasily in their present position. This uneasiness which is being felt by the competitive units of each industry, is also taking hold of those who are concerned with the trade balances of nations. Thus the British Parliament has declared that if Britain is to maintain her place in international trade, "The philosopher must bring his talents into the market place." This suggestion was the theme of a recent address before the Manchester Literary and Philosophysical Society, by Dr. Levinstein who pointed out that scientific men of the highest ability must be represented on the boards of directors which guide the expansion of British industries if the proper correlation between science and industry is to be obtained.

Our own men of science and industrial affairs are uniformly contending with Dr. A. D. Little that the "Handwriting on the Wall" as interpreted for the modern Belshazzars of industry dictates the necessity for research if the security of dividends is to be assured.

Granting that scientific research is to be relied upon more and more in the future to direct the expansion of old industries and to create new processes and products of which we know nothing at present, it is obvious that such activity will have a great influence on the manner in which future wars, if such there be, will be waged. It is a fact, the import of which cannot be minimized by refusing to admit it, that science has been used for grievous purposes as well as for improving the well being of mankind, and the more science is employed in peace-time activities to create agents conducive to the advancement of civilization, the more it must be reckoned with as a potential source of destruction in time of war. Science can transform, in a short time, factories which are engaged in the manufacture of drugs, dyes and other harmless materials into those which will produce explosives, poisonous gases, liquid fire and other agents which are important elements of modern warfare.

The last war was, more than any that preceded it, a war of chemicals, and it has been said that the chemical effort was second in importance only to the personal services of the men in the field. Thus it has come about that in addition to training men in the strategy of war and supplying them with ships and guns, it is necessary to consider science and industry in all their ramifications as essential parts of the weapon of defense.

In the Aeneid, Virgil declared he sang of arms and a man, but it is necessary now in singing of war to add an additional verse to his song—one which refers to the part played by science.

Immediately upon the entry of the United States into the World War, the necessity arose for extensive research in the chemistry of explosives. An organization was built up hurriedly at Picatinny Arsenal and a large force of chemists began work on a multitude of problems contingent to the supply of raw materials, propellant powders, high explosives, etc., which were necessary in furnishing ammunition in accordance with the general war program. The lack of basic scientific data on the chemical processes involved, and on the physical and chemical characteristics required of explosives for the various types of weapons, was keenly felt by those charged with the responsibility of organizing the chemical industry to meet the pressing needs of the time. It is only fair to say that the rapid progress made would have been impossible had it not been for the assistance afforded by the technical experts of the French and British governments. This situation, which arose suddenly and, after many months of serious concern, ended in the same manner, existed sufficiently long to set up a significant warning for the future.

In attempting to give calm but logical heed to this warning the Ordnance Department of the Army has gradually transformed the feverish research and development activities of the war period into a more substantial effort, an effort which it is expected will not only establish the best types of ammunition but also make possible their production, on fairly short notice, by the industries involved.

In the field of high explosives many problems requiring extensive research have compelled attention. These may be divided broadly into two classes, viz., those having for their purpose the eventual establishment of standard high explosives which will be the most efficient possible for the various uses to which they are applied; and those seeking immediate explanations for certain unsatisfactory conditions which exist in the present reserve supply of high explosive components. Problems of the first class arise partially from knowledge gained in the study of those in the second.

Many explosives used during the war were designed especially and more or less hurriedly for particular components such as grenades, bombs, trench mortar shell, etc., in order to permit the entire supply of the standard TNT to be used for artillery shell where the requirements are of necessity more rigid. These special explosives were soon found to have various objectionable features; some contained hygroscopic ingredients which absorbed moisture readily from the air, thus rendering the explosive insensitive to detonation, causing extreme corrosion of the metal components, and in a few cases developing dangerous decomposition of the explosive charges after they had undergone storage for a considerable time in warm climates. Even TNT, the prime military high explosive, was not entirely free from faults. Some shell loaded with it or with mixtures of it and other materials developed gas pressure upon storage while many others became contaminated with an oil which formed within the charges and collected in the booster cavities or even exuded from the nose of the shell, smearing the outer wall and thus rendering the ammunition unfit for use.

The chemical reactions responsible for such effects had to be determined in order to provide a satisfactory remedy. The influence of impurities present in the explosives, even those in minute amounts, has been studied and many of the difficulties solved by interpretation of the results obtained; some of these problems are still receiving attention in order to obtain a complete understanding of all factors involved. This work has led to investigations of manufacturing processes, special methods of purification, etc., with a view to establishing standard procedure which will enable the accepted explosives to be prepared free from all objectionable impurities. As a result of such studies the former specifications are being carefully revised to insure that explosives of wholly satisfactory quality will be obtained and yet avoid such rigid requirements

as would hamper large scale production; the proper balancing of these opposing factors requires extensive research and practical tests.

Since there is evidence that some of the present standard explosives, even when in a high state of purity, are scarcely capable of functioning ideally under the conditions of their use, it has been considered necessary to investigate new compounds and compositions with a view to effecting improvements beyond those possible by merely correcting certain faults in existing types. This work has involved the synthesis and study of the explosive properties of numerous compounds, some of which had not been investigated previously in this country so far as known. Valuable results have been obtained from these studies in that a few new explosives having properties which make them superior for certain specific purposes, can be prepared from entirely different raw materials than are required to produce the present standard explosives. It is recognized as imperative that all explosives which appear suitable for military use and which can be manufactured from readily available materials be studied, classified from the standpoint of their possible use for specific purposes, and processes developed for the manufacture of those shown by experiment to be capable of fulfilling ammunition requirements. If an emergency should arise and a shortage of raw materials for the manufacture of standard explosives should result—as it usually does—it would thus be possible to make use immediately of substitutes the properties and the methods of manufacture of which are definitely known. It is perhaps not an exaggeration to say that it was Germany's foresight in this particular direction which enabled her to maintain an unbroken flow of ammunition to the front in spite of the fact that her early calculations as to the length of the war and the amount of explosives that would be required were so greatly in error.

Analytical Work Room, Research Laboratory, Picatinny Arsenal.

In the development of improved propellent powders which are being designed to overcome the various objections to the standard nitrocellulose powder such as variable stability, extreme volatility and hygroscopicity, tendency to flash at the muzzle of the gun, etc., it is necessary to carry on considerable research to obtain the fundamental data required by those concerned with the design of such powders. Attempts to eliminate the volatile ether-alcohol solvent from finished powders has led to a study of the properties of many known solvents which might be substituted; these have been classified from the standpoint of their general suitability for the purpose and applied on a laboratory scale as colloiding agents for nitrocellulose. In this work numerous factors must be considered in addition to the general efficiency of the solvents in effecting gelatinization of the nitrocellulose. It is of importance that the colloiding agent be readily available, that it have no adverse effect on the stability of the nitrocellulose, and that it be non-volatile at elevated atmospheric temperatures and non-hygroscopic; it must also burn with sufficient speed that when mixed with nitrocellulose in the form of finished powder the latter can be adjusted to meet the ballistic requirements. In attempting to obtain and apply such information to the preparation of small lots of propellent powders certain irregularities in the action of the powders led to the view that the internal structure of the powder grains, i. e., the homogeneity of the colloid or gel had a connection with the uniformity of action of the powders. Accordingly, a study is being made to extend the information on this point.

Cellulose nitrate, after mixing with ether-alcohol or other solvent and passing through the pressing and blocking processes, is a colloidal mass of the gel type. This gel similarly to other common gels such as gelatine, flour dough, soap, etc., consists of two phases, the dispersed

phase and the dispersion medium, cellulose nitrate being the dispersed phase and the solvent the dispersion medium. Any gel may have the dispersed phase more or less uniformly distributed through the gel mass, the degree of homogeneity depending upon the manner in which the gel has been prepared, i. e., proportion of solvent, temperature employed, time of solvent action, etc. This implies that the gel structure is relatively unstable since the orientation of the molecular units is conditioned by many factors; there exists the capacity for rearrangement of the molecular units so that shrinkage may occur or segregation of the dispersed phase into clots or filaments, thus giving extreme inhomogeneity to the mass. Considering the fact that the cellulose nitrate gel prepared for extrusion in the form of powder grains contains 40 per cent or more of the solvent and this is reduced in the solvent recovery and drying processes to amounts varying from two to seven per cent, depending on the size of the powder grains, it is to be expected that considerable changes occur in the structure of the gel during this treatment. These changes are evidenced by warping of the grains, uneven contraction or shrinkage from one end of the grain to the other, etc. Attention is being given in the research work at the Arsenal to the internal structure of the powder grains as produced with various solvents and under various conditions, since it is considered that the condition of the grain with respect to fissures, clots or thread-like aggregates of segregated cellulose nitrate, presence of improperly dispersed nitrate, etc., will have a direct connection not only with the ballistic uniformity of the powder but with the chemical stability as well. A special microtome and high powered microscope are being used for the sectioning of grains and examining them at high magnification in order to assist in determining the relative efficiency of the various solvents under consideration.

While there have been extensive researches conducted on the purification of raw cotton and the nitration of it for use in smokeless powder manufacture, the present procedure followed from the time the cotton is picked until it is transformed into finished powder is based on the results of the earlier researches in this field. The war focused the attention of chemists, in all countries of the world, on cellulose and nitrocellulose and in the past few years knowledge of the chemistry of these complex substances has been greatly extended. Much of this is being made available in the chemical literature and portions of it with proper application may lead to marked improvements in the method now used for manufacturing smokeless powder. Special processes for purifying and further treating cotton prior to its nitration are being studied at the Arsenal laboratory and the effects of these on the ease with which the nitrocellulose is gelatinized and later freed from the solvent are receiving attention. Different lots of cellulose nitrate are known to give colloidal solutions of widely different viscosities when the solutions are prepared from the same solvent under the same conditions. This indicates that the present production method of mixing the nitrate with the same proportion of solvent in all cases will not yield a uniform mass from the mixers from day to day; considering the fact that the subsequent blocking and pressing operations are also standardized it is obvious that if they are carried out on a mass which varies in its degree of gelatinization the resulting powder will come from the graining presses varying in structure from lot to lot or even within a lot. Whether this variation is sufficient in practice to affect the ballistic uniformity of the powder may be questioned, but it is reasonable to expect that it is an appreciable factor; there is fairly direct evidence that it does affect other important properties of the powder. Experimental work with a view to improvements in this direction is being conducted and there is promise that it will result in economies of solvent necessary in the manufacturing process and also in giving propellent powder which will maintain its normal stability over longer periods of time.

Another line of investigation which has been followed at the Arsenal since the War relates to special delay powders for use in fuzes. Artillery shell and bomb fuzes, whether of the long delay or short delay type, usually obtain the desired time interval before functioning by burning a column or train of black powder. Since the length of the powder train is often limited by the design of the fuze the problem arises of producing a powder which will burn at such a rate that a prescribed length of train will give the time interval desired. With short delay fuzes where the time element is only a fraction of a second it is necessary that the powder burn with extreme uniformity if the action sought from the fuze is to be obtained. It has been found that for certain fuzes, black powder as commonly manufactured is not sufficiently uniform in composition or granulation that the small pellets used to make up the delay element will burn within the tolerances prescribed. In this connection, the precise effect of numerous deterrents on the rate of burning of black powder and the effect of variations in the proportion of the ingredients of the composition have been determined, thus enabling powder compositions to be chosen quite accurately with respect to their rate of burning, for any specific purpose. The difficult problem of securing such uniformity in composition that separate minute portions taken from a lot of powder would give pellets burning with the same rate within narrow limits was not completely solved until numerous refinements were made in the usual manufacturing process; some of these refinements which refer to more careful control of the condition of the raw materials, and to the pressing and graining operations are considered marked improvements over present commercial practice.

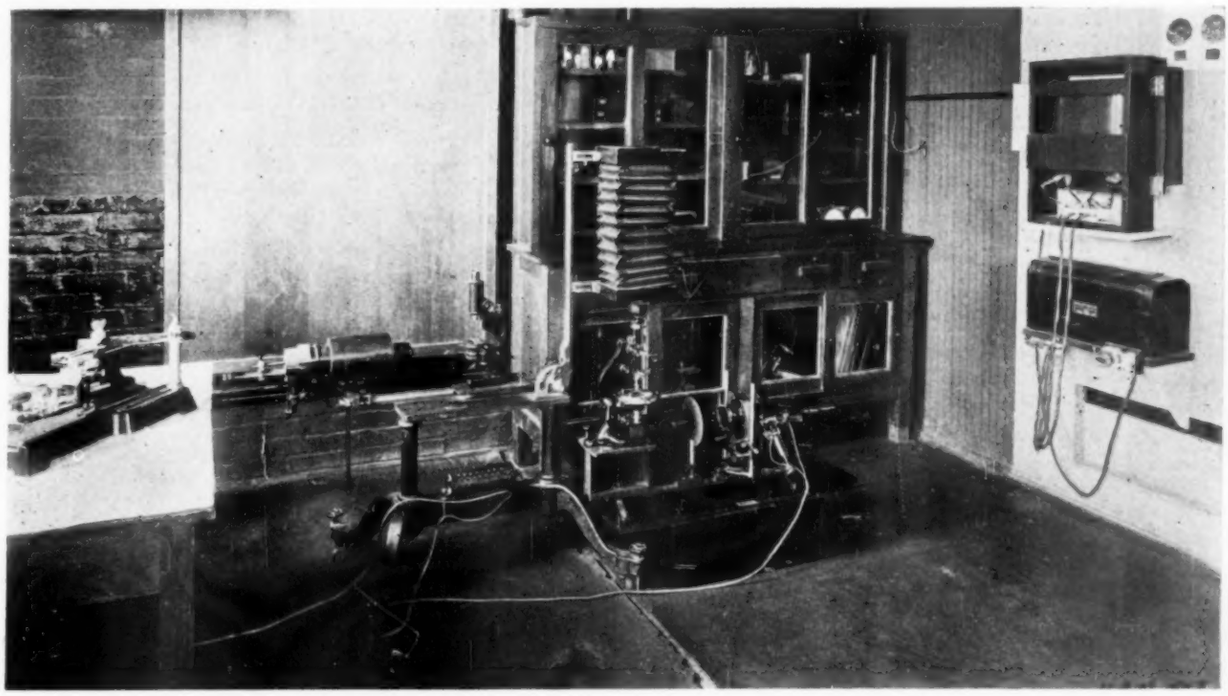
In attempting to employ a certain fuze of old design under conditions imposed by modern warfare it was found that the delay train of black powder was wholly inadequate; the inherent objection to the powder could not be overcome by introducing carefully considered variations either in the composition or the method of manufacture. To meet this situation a special powder made up of raw materials not previously used in the explosive industry is being developed. Certain special features of this powder offer promise of a substantial improvement in such delay powders as are required to function under the most adverse conditions.

Another interesting phase of the research work in progress at the Arsenal comprises a study of the fundamentals

underlying the application of pyrotechnics for signal and illuminating purposes in modern warfare. In attempting to apply known pyrotechnic compositions for signal and illumination purposes on the battlefront, certain demands arose as to the purity of color and intensity of the light produced, the range of visibility of the signals, etc., in order that uniformly efficient action could be obtained. Although considerable research work was done along this line by the Ordnance Department during the War, time was not afforded to cover more than the most urgent problems of the moment. A separate laboratory is now maintained at the Arsenal, equipped with standard instruments for measuring the various factors which determine the luminous effects produced by pyrotechnic compositions. A full unnderstanding of the physico-chemical characteristics of all pertinent compositions handed down by the art is being obtained with a view to effecting improvements where deficiencies exist. New compounds and compositions capable of producing light of limited wave length are being investigated and efforts made to determine the range of visibility of signal lights under the wide variety of atmospheric conditions met with in the field. The stability and other properties which indicate the hazard involved in manufacturing and handling pyrotechnic compositions is also being studied since there is an utter lack of definite information along this line.

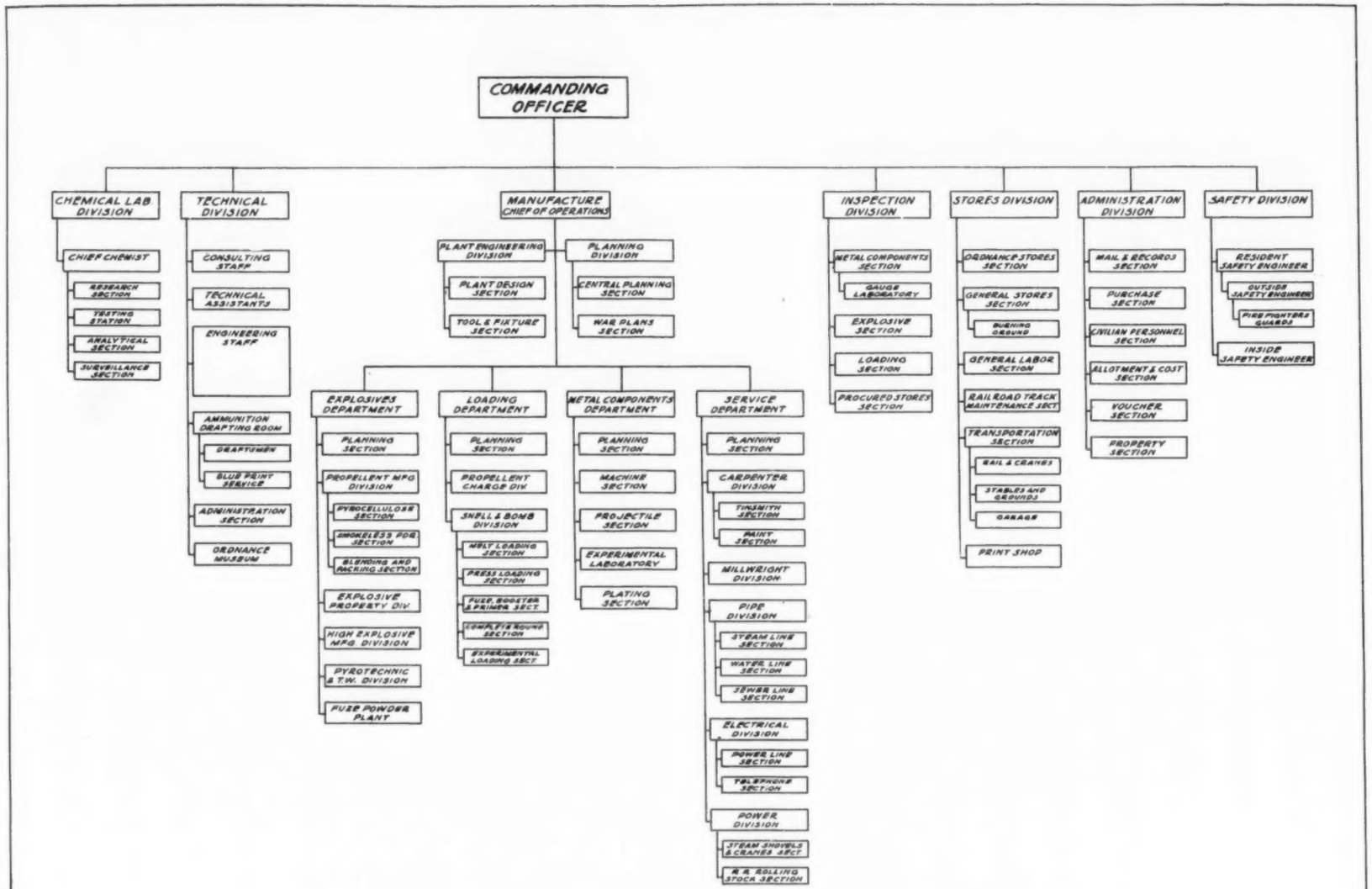
When sufficient fundamental data have been obtained it is hoped that specifications can be drawn for any given pyrotechnic device, which will insure the maximum uniformity of action in service and which will make possible the rating of all signal devices with respect to the range at which they are effective under conditions of both day and night use.

In order to keep abreast with developments in those industries which are of vital concern to the Ordnance Department in time of war, it is necessary that a research organization function to a certain extent as an intelligence department. Numerous patents bearing directly on problems under investigation appear from time to time, and many articles are published in the current scientific journals, which contain information of the highest practical value. Various journals, both domestic and foreign, dealing with chemistry, physics and engineering are received at the Arsenal, carefully reviewed and placed in the laboratory library for reference. A patent file which includes all U. S. patents pertaining to the explosives and pyrotechnic industries is also maintained.



A Corner of the Photomicrographic Room, Research Laboratory, Picatinny Arsenal.

The necessity for such work as is briefly and only partially discussed above is apparent with very little reflection. The activities of the Ordnance Department are of a specialized nature. They are such as to require enormous expansion within a very short time in case of emergency. During peace time the industries give little attention to ammunition problems since there are few contracts and practically no incentive for conducting research toward improving explosives or other essential elements of ammunition as required for military purposes. In time of an emergency they look to the Ordnance Department for advice as to the needs of the moment and generally for help in establishing the proper procedure for supplying these needs. The practice both in the industry and in the using services of the Army expects the Ordnance Department to know definitely what is wanted and to be prepared to act as scientific expert, counselor, and business agent in the procurement of all Ordnance matériel. The industries and the forces in the field cannot render their maximum service to the country unless science has previously pointed the way.



ORGANIZATION DIAGRAM OF INDUSTRIAL ACTIVITIES
PICATINNY ARSENAL, 1926.

Organization and Administration of Development Work at Picatinny Arsenal

Maj. H. H. Zornig, Ord. Dept. U. S. A.

MODERN ammunition has reached such a stage of complexity that no one individual can be expected to be expert in all the branches of science, engineering, and manufacturing technology which are involved in the design and production of a complete round. As a natural consequence of this condition, we find today that the individuals interested in the development and production of ammunition have a more or less general knowledge of the whole subject, but have expert knowledge and skill in only one or two branches of it. Such individuals, working by themselves, may make improvements in those components of which they have special knowledge, but improvements in individual components seldom affect the maximum betterment of the complete round unless one or more of the other parts are designed in such a way as to take advantage of these improvements. Since the betterment of the complete round is the sole object of all development work in ammunition, it becomes evident that it can best be secured through the carefully coordinated work of a number of individuals whose combined expert knowledge covers the whole subject of ammunition. This at once points to a development organization of suitably qualified experts with the necessary coordinating control and administrative procedure. This condition is thoroughly realized by the Ordnance Department and since the World War it has been developing such an organization at Picatinny Arsenal.

Experience at Picatinny Arsenal has led to the division of its development activities into three phases. These have been designated, more or less appropriately, the engineering, research, and production phases. While they are distinct, a sharp dividing line cannot be drawn between them and they do in places overlap to some extent.

In the engineering phase the principal activities included are:

The continuous study of the requirements of the using services and their experience with types of ammunition with which they are supplied.

The continuous study of progress in science, engineering, and manufacturing technique, and the application of pertinent developments to the improvement of ammunition.

The design of new and improved materials, components, and complete rounds, including the preparation of drawings and specifications, and the technical direction of their manufacture and test during the development stages.

The formation of plans for the research and development work in manufacturing technique which should be done to make possible further improvements in ammunition.

The coordination of the activities included in the research and production phases.

Transmitting to the storing, maintaining, and using services the knowledge of those technical features of ammunition which they should have to enable them to take full advantage of its possibilities.

The research phase takes in those activities concerned with:

The research work on those problems in pure science which are likely to be of interest in ammunition development.

The research work which has for its objective the solution of a definite problem which has been encountered, such as the production of a new explosive of given characteristics or the determination of data needed to work out the design of a new component.

The laboratory work which is necessary in devising and developing a manufacturing process, particularly that work which is necessary before a semi-plant scale unit can be built.

The production phase embraces those activities involving:

The manufacture of materials, mechanisms, components or complete rounds for experimentation or test.

The development of manufacturing processes, equipment, and technique.

The critical study of new designs of ammunition components with a view to their modification, where possible, to facilitate production.

The development of means for the instruction of inexperienced commercial manufacturers in the methods which have been developed for the manufacture of any ammunition or components they may be undertaking to produce.

Each of these phases of the work requires a personnel with a particular training and viewpoint. Each requires facilities of a particular kind and each requires an administrative procedure adapted to its particular needs. This has led to the separation of the development organization at Picatinny Arsenal into three main divisions, namely, the Technical Division which is responsible for the engineering phase of the activities, the Laboratory Division which handles the research phase, and the Manufacturing Division which takes care of the production phase, and in addition manufactures such standard ammunition for issue as the Arsenal is required to produce.

Under this assignment of duties the Technical Division is directly charged with responsibility for the progress made by the Arsenal in the development work assigned to it. This division operates as a staff division and exer-

cises its coordinating and supervisory functions in the name of the Commanding Officer. Its work is carried on by its Engineering Staff which is headed by the division chief and his assistants and assisted by such auxiliary sections as the Drafting Room, Stenographic and Typing Sections. The Engineering Staff is divided into five sections, to each of which is assigned the responsibility for a definite region of the ammunition field. In making these assignments an attempt was made to divide the field so that the work covered by each section corresponded as nearly as possible to the divisions of scientific and professional work which exist in civil life. The sections and the fields covered by them are:

Propellant Section—covering propellents and propelling charges.

High Explosives Section—covering high explosives, explosive trains, and bursting charges.

Fuze Section—covering all kinds of fuzes and firing mechanisms.

Projectile Section—covering all kinds of missiles (Projectiles, bombs, grenades, etc.) and cartridge cases.

Pyrotechnic Section—covering all kinds of pyrotechnics.

The personnel in each of these sections of the Engineering Staff is expert in the particular field covered by its own section, and in addition has a general knowledge of the fields covered by other sections. The direction of the work of the sections, each with its special knowledge and interests, so that they will function as a unit with one interest, namely, the improvement of the complete round, is the work of the chief of the division and his assistants.

The assistants to the Chief of the Technical Division are first of all his technical advisors and as such are chosen for their technical training. They are three in number, one with special training in chemistry and chemical engineering, one with special training in mechanical engineering, and the other with a special knowledge of the requirements of the using service, and the use of ammunition by the troops. To these assistants have been delegated all the supervisory and coordinating duties of the chief of the division, to be carired out in accordance with his policies. This arrangement of assistants and assignment of duties has been chosen for several reasons, first—to supply the Division Chief with an independent source of technical advice, second—to provide for the efficient performance of the necessary supervisory and coordinating work, which, if attempted by the chief of the division personally would have to be slighted because of its volume and because of other demands upon his time, and third—to provide a directing organization capable of giving continuity to the work of the division in spite of transfers in personnel which so often take place in military organizations.

In the Laboratory the problems included in the research phase of the development work are assigned to individual members of the Research Staff. The members of this Staff are men with essentially scientific training, and while they are each expert in some particular branch of science and its particular application to problems relating to ammunition development such as, for instance, the colloidal chemistry of smokeless powder gels, the chemistry of high explosives, the physical testing of explosives, and others, they are not familiar with the subject of ammunition design except in a general way. Also they have the research type of mind and do their work with their own hands or with the help of a small number of assistants and the routine sections of the Laboratory. The Laboratory functions as an operating organization and to facilitate the coordination of its work the Chief of the Technical Division is also Chief of the Laboratory Division. The actual control of the Laboratory, however, is delegated to the Chief Chemist.

The Manufacturing Division has available for carrying on the production phase of the development work the whole of the manufacturing facilities and operating personnel of the Arsenal. It has a planning organization for carrying on the administrative work, an engineering organization for designing new plant equipment, tools, etc., a construction and maintenance organization for building, installing and maintaining it, and an operating organization for developing the operation of new or improved processes and for the manufacture of components and rounds of new design. In addition to its development work the Manufacturing Division is constantly engaged in the production of small quantities of standard ammunition components. This work is of great importance, not only because it provides for the production of those ammunition components for which manufacturing facilities at the present time do not exist elsewhere, but also because it enables the Ordnance Department to maintain a small personnel skilled in the art of ammunition manufacture, which will be available for the instruction of new manufacturers in an emergency, and it provides work for the personnel required to carry on the production phase of development work during the intervals when such work is not available.

The individual experts required for the development of ammunition are provided by the three divisions of the development organization just described. The coordination of their work is secured through a carefully laid out scheme of technical administration which is designed to indicate definitely to each individual the part of the development field in which he is to work and for which he is held responsible, to provide each with the facilities and means necessary to carry on the work assigned to him, to provide such supervision of the individual's work as is necessary to insure that it is being carried on in accordance with the general policies of development and with the more specific technical plans, taking care to leave to each the greatest possible freedom consistent with the attainment of the end in view, and to provide positive means for bringing the results of research and development work to the attention of the interested persons and insuring its use in the improvement of ammunition when applicable.

The first step in this scheme involves a continuous careful study of the whole ammunition problem and the establishment of general development policies, the determination of the objectives to be reached, the general lines to be followed in reaching them, and their relative importance. In this step cognizance is taken of the requirements of the using services, the policies and orders of the Ordnance Office, the experiences of Field Service and the using services, the experiences of this Arsenal and other manufacturers of ammunition, and all other pertinent information from whatever sources obtainable.

The second step consists of a division of the work thus

decided upon into definite parts or projects, each of such a nature and extent that it can be assigned to some individual for execution. Experience has shown that the number of projects thus established are greater in number than can simultaneously be handled by the organization which the available funds will maintain. This necessitates a study to determine the relative importance of each project and a determination of the proportion of the available effort of the organization that each will receive. The result of this study is the assignment of a definite amount of money for the accomplishment of the work covered by those projects which are to be worked upon at the time and the assignment of a priority to each. The development projects thus provided for are each assigned to some individual in the development organization, who is designated as the "Engineer in Charge" and is held responsible for carrying out the work covered by them. Projects dealing with the engineering phase of the development work are usually assigned to members of the Engineering Staff, those dealing with the research phase, to the Chief Chemist or members of the Research Staff, and those dealing with the production phase, to the personnel in the Manufacturing Division.

The plans, which up to this point have been formulated by the Chief of the Technical Division and his assistants, other divisions of the development organization assisting where subjects in which they have a special interest are involved, must now be communicated to the persons who are to carry out the work in such a manner that each understands exactly what part of the work he is responsible for, the objects to be attained, and the relation of this work to the whole problem. If these points are made clear and the division of work has been correctly made, very little difficulty is experienced in getting the engineers in charge to manage their projects in conformity with the broader development plan of which they are a part. To aid in securing this correctness of planning and understanding, it has been found desirable to prepare a written statement covering each project, setting forth its scope, its relation to other projects, and the object to be attained. These statements are called "Technical Plans."

In some cases the preparation of these Technical Plans is a very simple matter, the data being often taken directly from reports of Boards, Minutes of the Ordnance Committee, official correspondence, or other sources. At other times their preparation becomes a difficult matter and requires much study. While the preparation of the Technical Plans is a responsibility of the assistants to the Chief of the Technical Division, they are very often the results of conclusions arrived at after more than one conference attended by those members of the Arsenal organization who are interested in the project or have special knowledge of the subject covered. At these conferences the methods to be employed in carrying on the work covered by a project are often discussed, and although they are sometimes mentioned in the Technical Plan, the general policy is to leave the methods to be employed as much as possible to the discretion of the Engineer in Charge.

Formal authorization for the work covered by a development project and formal assignment of funds is accomplished by issuing an expenditure order (work order). Under this order the Engineer in Charge may have suborders issued to cover such labor, material, equipment, etc., as he may require to carry out the project for which he is responsible, so long as the cost thereof does not exceed the amount of money assigned.

Having thus been informed of the scope of his project, its relative place in the broad development plans, and its object, and being provided with the funds which are available for carrying it out, the individual in charge is given as much freedom of action as his ability and other circumstances in the case will permit. He is encouraged to exercise his initiative and ingenuity and to seek the advice and cooperation of other members of the organization who may have special knowledge bearing on his problems. Technical supervision of his work is limited as much as possible to helpful suggestions and constructive criticisms. This policy, it is believed, will develop a man's ability to its maximum and at the same time secure from him the application of his best efforts to the accomplishment of the work at hand.

Experience has shown that the work covered by each project is usually so extensive and of such a nature that it can be subdivided into several distinct but closely related problems, and it has been found advantageous to have individuals in charge of projects make such subdivisions. For each problem they prepare a program which outlines briefly the object to be accomplished, the relation of the problem to the project as a whole, and in a general way the methods to be pursued in its solution. By requiring approval of programs before permitting work to be started an *a priori* check is obtained that the work which is proposed will contribute to the end set forth in the Technical Plan, and that proper thought has been given to its planning. These problems when appropriately numbered for identification also afford convenient units for reporting, for administrative record, and for follow-up purposes. Those in authority must here realize that unless considerable liberality is shown in the consideration of programs for approval, and that it is understood that changes in the procedure as planned will very often become desirable or necessary and must be permitted, there is a danger of curbing or destroying the initiative of those writing the programs.

The engineer (or chemist, physicist, etc.) in charge of a project now proceeds to cary out the work he has laid out. If he has a research problem he will probably do the work himself or with the aid of one or two assistants, or if the problem is one involving the design, manufacture and test of a component, he will probably personally supervise the work of the draftsman drawing up the design, have the Manufacturing Division manufacture the desired number of samples according to his drawings, and have these samples tested by the Testing Ground personnel in accordance with his instructions.

Individuals in charge of projects are required to make a technical report upon the completion of each problem for which they are responsible. These reports are critically examined in the office of the Chief of the Technical Division. It is his responsibility that the information contained in them receives the proper local distribution and application, and that the appropriate papers for trans-

mitting them to the Ordnance Office, with the Arsenal's comments or recommendations, are prepared for the signature of the Commanding Officer.

Once each month the Chief of the Technical Division or his assistants hold a formal conference with all individuals in charge of projects at which the progress of work and general technical questions are discussed. The more specific subjects are taken up in informal conferences, held whenever the necessity therefor arises.

It is evident that the Ordnance Office must be kept fully informed of the Arsenal's development plans, the progress being made, and the results being obtained. With administrative procedure just outlined it is possible to supply this information with a minimum of effort. The general development plans are shown on a series of charts on which are listed in logical groups all the active development projects, the coresponding expenditure order numbers, the distribution of the development funds allotted to the Arsenal, the priority assigned to each project and other similar pertinent information. Photostat copies of these charts furnished the Ordnance Office once each month and these together with copies of the technical plans covering the projects and the programs covering the problems, forwarded as they are written, give general and detailed information regarding the development plans. Notations made on the charts, after the monthly conferences, and before the charts are photostated give information of the progress of work, and copies of technical reports with the transmitting comments and recommendations give information regarding the results obtained.

It is in some ways unfortunate that a great deal of the technical knowledge which exists regarding ammunition design and manufacture has never been collected in such form that it is readily available to persons who have not had a considerable intimate contact with the subject. In peace times there are relatively few people engaged in the industry and they, probably on account of the restrictions usually placed upon the publication of such material, have not to any great extent collected the available information into such readily usable form as has been done with that pertaining to some of the more generally practiced branches of engineering. While the lack of such a collection of critically selected data seriously hinders the rapid training of new men in the ammunition industry even in peace time, it is at the beginning of an emergency, when a large number of men trained in more or less closely allied lines will be required to quickly assume technical responsibilities in connection with ammunition, that this lack is going to be most seriously felt and may even become critical. With a view to remedying this condition the scientific and technical personnel at Picatinny Arsenal is attempting to gradually collect, coordinate, and put into handbook form that mass of specialized information relating to the subject of ammunition which now is in the possession of the older and more experienced ammunition men, in written or unwritten form, in the technical files of the Ordnance Office, this Arsenal, and other accessible places, and in the less well known publications, and adding that which is being continually obtained in connection with current work. At present this is a purely local undertaking, being carried out solely for the convenience of the Arsenal personnel. It is, however, hoped that in time the "Picatinny Arsenal Handbook for Ammunition Engineers" will come to be to the ammunition engineer what "Marks" or "Kent" is to the mechanical engineer.

In the foregoing an attempt has been made to describe briefly the form of the development organization at Picatinny Arsenal and the principal features of the administrative scheme adopted for coordinating and directing the work of that organization. While it is believed that a good form of organization and scheme of administration are indispensable in directing the efforts of a group of individuals to the efficient accomplishment of a definite piece of work, it is also thoroughly understood that no form of organization or scheme of administration, however good they may be, can take the place of character and ability in the individuals who comprise the organization.

Robert S. Brookings Addresses Army Industrial College Graduates

THE graduation exercises for the fifth class of the Army Industrial College were held in Washington, June 28, 1926. Diplomas were presented by Hon. Dwight W. Davis, Secretary of War. Robert S. Brookings, President of the Board of Trustees, Washington University, St. Louis, Mo., who is also President of the Institute of Economics and Government Research, Washington, D. C., made the principal address. Mr. Brookings was a member of the War Industries Board in 1917.

Recalling conditions which existed incidental to the procurement program during the World War, Mr. Brookings told the graduates that the purpose of the Army Industrial College was to guard against a repetition in this respect by planning mobilization of industry and economic procurement in the event of another emergency.

The graduates were: Maj. Keith F. Adamson, Ord. Dept., U. S. A.; Capt. John Biggar, Q. M. C., U. S. A.; Capt. Emil H. Block, Q. M. C., U. S. A.; Maj. James H. Burns, Ord. Dept., U. S. A.; Maj. Samuel S. Creighton, M. C., U. S. A.; Capt. Oliver P. Echols, A. S., U. S. A.; Maj. Edmund deT. Ellis, Q. M. C., U S. A.; Maj. Charles T. Harris, Jr., Ord. Dept., U. S. A.; Lt. Col. John E. Hemphill, S. C., U. S. A.; Maj. Jeter R. Horton, U. S. M. C.; Lt. Col. John B. Huggins, M. C., U. S A.; Lt. Leland C. Hurd, A. S., U. S. A.; Lt. Cortlandt S. Johnson, A. S., U. S. A.; Maj. Byron Q. Jones, A. S., U. S. A.; Maj. Norman L. McDiarmid, M. C., U. S. A.; Comdr. Frederick V. McNair, Jr., U. S. N.; Capt. Jerry V. Matejka, S. C., U. S. A.; Capt. Charles J. Morelle, Q. M. C., U. S. A.; Capt. Edward S. Pegram, Jr., C. E., U. S. A.; Maj. Alfred L. Rockwood, C. W. S., U. S. A.; Maj. Bethel W. Simpson, Ord. Dept., U. S. A.; Maj. Robert Skelton, M. C., U. S. A.; Col. Frederick W. Van Duyne, Q. M. C., U. S. A.; Maj. Herbert J. Wild, C. E., U. S. A.; Maj. Glenn P. Wilhelm, Ord. Dept., U. S. A.; and Maj. Maurice B. Willett, C. W. S., U. S. A.

Instructors during the school term just closed were: Lt. Col. George E. Kumpe, S. C., U. S. A., and Maj. Rudolf W. Riefkohl, Q. M. C., U. S. A.

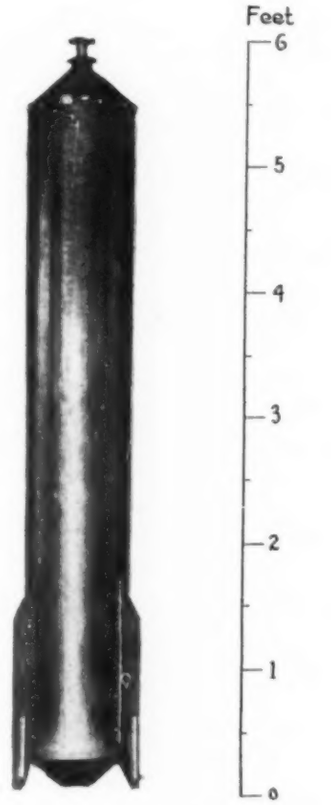
Pyrotechnics

Capt. Ira A. Crump, Ord. Dept. U. S. A.

UP TO the present time no claim has been advanced by any one that the World War was won by pyrotechnics. In this respect pyrotechnics occupy a unique position, and it is not the intention of this article to take away this distinguishing characteristic. However, it is true that in the past, campaigns and wars have been won by the use of material that would now be classed as pyrotechnics. The literal meaning of the word pyrotechny is "the art of fire," but obviously this definition is too broad to be applied to the present division of military material known as pyrotechnics which is limited in its military meaning to devices used for signaling and illuminating purposes.

Although the use of fire and consequently the means of illumination extends far back to the beginning of recorded history, it was not until long after the beginning of history that any systematic use of fire and light as military weapons was made. Gideon, according to the Bible, made use of a simple but very effective pyrotechnic device when he and a small band of Israelites routed the Midianites with lamps hidden in pitchers. Each man carried a pitcher in one hand and a trumpet in the other. At the proper moment the pitchers were broken and the trumpets sounded, and it is recorded that the defeat of the Midianites was complete.

Greek fire was one of the first successful pyrotechnic devices which could be projected or thrown a short distance, and its effectiveness was thereby increased many fold. The use of Greek fire died out with the advent of gun powder, but the signal rocket, the origin of which is lost in obscurity, is another pyrotechnic device that has remained in use until the present day. Ordnance Manuals of the United States Army published in 1849 and 1861 discussed under the headings "Incendiary Compositions, Lights and Signals," the various pyrotechnics then in use in the Army, the principal items being rockets, fire balls and torches. Prior to the World War the pyrotechnics in use in the United States Army consisted of signal rockets and the ten gage Very pistol cartridges loaded with illuminating and color signals. These were procured in small quantities by the Signal Corps, Coast Artillery, and Engineers.



Experimental 1,000,000 Candle Power Illuminating Flare.

When the United States entered the war a survey of the requirements for pyrotechnics showed that all the material on hand should be declared obsolete. To design the pyrotechnics required by the Army, a Pyrotechnic Section was created in the Trench Warfare Branch of the Engineering Division of the Ordnance Department, and a Laboratory was established at the American University, Washington, D. C. This Section developed its own designs and production had started when the American Expeditionary Forces made a recommendation that the French program of pyrotechnics be adopted by the United States. This was done, although it meant a fresh start and the scrapping of all the work which had been done up to that time. Orders coming from France in the spring of 1918 changed the caliber of the Very pistol to 25-mm. and brought into our requirements about sixteen different styles of star and parachute cartridges. In addition to these there were required about twenty styles of star and parachute cartridges for the French V. B. (Viven and Bessieres) dischargers. In addition another recommendation from France brought in thirteen new styles of signal rockets, as well as smoke torches, wing-tip flares for airplanes, parachute flares for lighting the ground under bombing planes and twelve styles of cartridges for a new 35-mm. Very pistol for the use of the Air Service.

After these instructions had been received there was great uncertainty as to the quantity of each item that should be produced, and this question was not settled until August, 1918, when a large program of requirements was issued. At first it seemed that it would be necessary to build new factories, but after a careful examination of the existing facilities it was found that they could be expanded to take care of the production. Before the Armistice stopped production, hundreds of thousands of signal rockets, position lights, rifle lights, V. B. cartridges, Very pistol cartridges, and airplane flares had been produced. Notwithstanding the quantities of pyrotechnics that were manufactured in this country, only a small percentage reached France before the Armistice. The pyrotechnics that were manufactured and used during the war were not in general very

efficient in performance. Many failures and malfunctionings occurred which were probably due to too light construction and lack of waterproof features which would enable the pyrotechnics to stand up under storage conditions at advance depots.

Pyrotechnics have never been considered among the major items of war material, but no satisfactory substitutes have yet been found for pyrotechnic signals and illuminants, and until that time comes, if ever, experimental and development work must be carried on to produce pyrotechnics for issue to the Army for peace-time training and to have designs ready for production on a large scale should any emergency arise. Consider the experience of the Army upon its entry into the last war. There was no central control over the procurement of pyrotechnics, existing types were declared obsolete, and no new designs were ready. A start was made and then it was found necessary to drop the adopted line of development and take up another with the results mentioned in the preceding paragraph. Such an experience should not be repeated. No commercial concerns are engaged in producing pyrotechnics which are suitable for military purposes, all of their products being intended for quick consumption and not having the durable and waterproof features required of ammunition, for as such military pyrotechnics are classed. With the large increase in the use of airplanes in warfare, pyrotechnic requirements will undoubtedly be much greater than ever before should another war come. The Ordnance Department is, therefore, obligated to pursue the development of pyrotechnics in order to perfect designs which will meet the requirements of the Army and which will be capable of quick quantity production.

Late Type of Airplane Landing Flare with Folded Parachute.

A Pyrotechnic Board was appointed in 1919 by the War Department for the purpose of developing a system of pyrotechnic materials, and shortly after this Board made its report the Pyrotechnic Unit was established at Picatinny Arsenal. This Unit has since that time been carrying out experimental and development work to meet the recommendations of the Pyrotechnic Board and manufacturing and supplying the Army with pyrotechnics for training purposes.

The Unit when it was established in the latter part of 1919 consisted of two buildings and a staff of three men. At the present time it consists of a small machine shop, two rows of small mixing and charging buildings, a photometric gallery, equipment for making spectrographic examination of signal lights and the necessary store houses, in all about twenty buildings. The personnel numbers about fifteen men and women. The Unit is planned so that it can be made into a large production unit on short notice.

The Pyrotechnic Board made a thorough investigation of the functioning and effectiveness of signals and flares then in use by the Army. A great deal of information was considered and the first conclusions reached were that the number of signals should be reduced, as too many signals cause confusion in actual warfare, and that the new signals should be more efficient and more durably constructed. To quote from the Board's report, "In general all of the present types of pyrotechnics fall within the class of fire-works and not Ordnance. In making recommendation for specifications covering all the types specified the Board is influenced by this consideration and cannot lay too much stress upon the importance of recommending the development of pyrotechnics along the lines of other Ordnance matériel."

The Board then recommended work on the following number of signals: *Non-Projected Signals*, for ground troops and air service, 5 signals; *Projected Signals*, for ground troops, 7 signals, for day and night use; for air service 12 signals, for day and night use.

The total number of signals recommended as compared with the number in use at the end of the war showed a decrease of 55.

The Board further recommended that the then existing methods of projecting pyrotechnics including rockets, Very pistols, and V. B. cartridge dischargers, be declared obsolete and that in their stead one method of projection of ground troop signals and one method for the Air Service signals be developed.

The action of the Board in declaring obsolete the old methods of projection, coupled with its recommendation that pyrotechnics be taken out of the fire-works class and that future development should be toward producing more substantial designs which would be waterproof, efficient and durable, meant that the new pyrotechnic unit, which was soon to be established at Picatinny, had to redesign and develop almost an entirely new system of pyrotechnics.

The Board in its report was not so severe with the existing types of position lights and wing-tip flares and stated that the designs then in use were fairly satisfactory. However, early in 1923 the Air Service requested that a new and improved wing-tip flare should be developed. Wing-tip flares are used by the Air Service for landing planes at night, one flare being placed underneath the outer end of each wing and lighted by an electric squib controlled from the cockpit. The flares are lighted when the plane is about 300 feet above the ground. The new type of flare requested by the Air Service has been developed and is now being manufactured for their use. Orders are also being received from the Navy for these flares. The present type has a burning time of two minutes and about 45,000 candle power. This type is considered very satisfactory, and it is probable that no additional development work will be necessary in the near future.

Position lights were used during the last war to outline front lines and troop positions to airplane observers. These lights were made in red, white, and green, and are comparatively simple in construction. They were considered quite effective in operation, but a new type is desired that will be waterproof and which will better stand the

rough usage encountered in service conditions. A new type is under consideration, and it is expected that it will be ready for test during the coming year.

Soon after the report of the Pyrotechnic Board was made the War Department decided that it would be desirable, if possible, to develop a system of projected signals which could be used by both the ground troops and Air Service. However, it was soon found that the length of delay fuze required for Air Service and ground troop signals is quite different, and in addition the propelling charge is not the same. This meant that if the same design was to be used for both services a complicated fuze mechanism would be necessary. The idea was soon abandoned and separate signals for ground troops and for the Air Service were taken up.

Wing Tip Flare and Holder.

The essential parts of a signal cartridge for both Services are primer, fuze, fuze housing, fuze housing cap, signal element, signal element tube or housing, propelling charge and expelling charge. These parts are all assembled in one complete round. The fuze housing in addition to containing the fuze contains the propelling charge. The fuze housing cap contains the primer and keeps the propellant in place in the fuze housing. The tube which contains the signal element is attached to the other end of the fuze housing. This complete round is placed in a projector and when fired only the fuze housing cap remains in the projector. The fuze housing and tube containing the fuze and signal are projected into the air and at the highest point of the trajectory, the fuze having burned through lights the expelling charge which shoots the signal out of the tube and at the same time ignites the pyrotechnic composition. A little reflection will convince any one that a successful solution of the problems presented in the design of a signal is not so easy as it appears on first thought.

Extensive development work has been carried out at Picatinny Arsenal since 1919 on the development of Air Service signals and at the present time three types of signals have been developed and approved for manufacture and issue to the service. These are: Green chain with parachute; white star, cluster; yellow smoke, parachute.

Although not yet approved for manufacture and issue to the service development work is completed on the white chain with parachute signal. In addition three other signals have been developed to the point where they are to be sent out to the using service for test. Further experimental and development work must be carried out with the following signals: Green, single star, with parachute; green, star, cluster; message signal.

Coincident with the work on the Air Service signals, work has been carried out in the development of ground troop signals. Although similar types of signals are used for both the Air Service and ground troops, the ground troop signals cannot always be made in the same manner as signals for the Air Service. One of the requirements for the ground troop signals is that they must be capable of being projected to a height of not less than 600 feet. Some difficulty was experienced in getting this height, but this difficulty has now been overcome. The force of setback on a signal which is projected 600 feet in the air is considerable and the illuminant or color composition must be capable of withstanding this force without breaking up. Six hundred feet may seem like a very small height to attain but considering the limitations placed on the designs, one pound maximum weight of signal, three pounds maximum weight of projector, and a color or illuminating composition which will withstand setback without breaking up, this height is not so easily reached. The following signals have been developed to the point where they are considered satisfactory as to the signal elements: Red, single star, with parachute; yellow smoke with parachute; white single star with parachute; red chain with parachute: red star, cluster; white, smoke.

Now that the proper height of projection has been reached it is expected that service tests of all these signals will take place in the near future.

Since signals for night use must be easily identified in the dark, markings that are distinguishable by touch are necessary. Accordingly a scheme of marking the cartridge cases with knurled bands has been devised to enable signals to be identified by touch. The position of the knurled band or bands at the top, middle, or bottom of a signal indicates the color, red, white, or green, the number of bands indicates whether the signal is a cluster, chain, or single star. In addition all signals are marked for visual identification by raised letters in the closing caps on the end of the signal.

In general, signals, like projectiles, are of no use unless they are projected to the proper spot before they function. Therefore, projectors for pyrotechnic signals are necessary. As previously stated the Pyrotechnic Board recommended that all the old types of projectors, rockets, Very pistols and rifle grenade dischargers be declared obsolete. The Air Service had objected to the Very pistol on account of frequent hangfires which necessitated throwing the pistol overboard just when it was most needed, and instances of planes being set on fire on account of hangfires are on record. The first development for the Air Service after the war was a grenade type of signal which did not re-

quire a projector, but this was unsatisfactory, and the next step was the design of the present type of signal cartridge which requires a projector. The projector designed is simple in construction, small in size and light in weight, the principal parts being made from aluminum castings. With this projector, if a hangfire occurs, the operation of opening the projector forces the whole signal cartridge to drop out of the projector and away from the plane. This type of projector has proved so satisfactory that it has been adopted for use by the Air Service.

In developing a projector for ground troop signals the recommendations of the Pyrotechnic Board have been followed as far as possible. The requirements were that it must be simple in construction, durable, weight not to exceed that of the service rifle, capable of projecting a signal to a height of at least 600 feet and constructed to receive the signal cartridges in the form of fixed rounds. The development of a discharger was complicated in the beginning by the desire of the using service to have a discharger which could be used for both pyrotechnic signals and rifle grenades. These early developments led to a point where it became necessary for the Infantry to chose one of several types. Five projectors were sent to Camp Benning for test, and as a result of this test preference was expressed for the bayonet tromblon type. The requirements for this type remain about the same as for the original type recommended by the Pyrotechnic Board, except the weight limit was decreased to 3 pounds. The present bayonet tromblon type of projector is muzzle loading, and designed primarily for use with signal cartridges only, but otherwise it has been developed to a point where it is considered satisfactory. Two of these projectors are being manufactured for service test by the Infantry and Cavalry Boards. Future development of the ground troop projectors will be to design and construct a breech loading projector which will embody as nearly as possible all the features which are at present considered desirable and which will satisfactorily fire the newly developed signal cartridges.

The only airplane flare in use by the United States Army during the last war was a copy of the French flare. Due to the large number of failures in functioning and a desire for a more efficient flare the Pyrotechnic Board laid down recommendations for two new types. Each was to be equipped with a time fuze to permit functioning at a prearranged distance below the plane. One type was to give 700,000 candle power with a burning time of 3 to 4 minutes, the other 300,000 candle power with a burning time of 7 to 8 minutes. Development work on these flares was progressing and six experimental types had been designed and three types tested. This experimental work was discontinued, and had not again been resumed, when the Air Service put in an urgent request for the development of a night landing flare. These landing flares were to be carried in night flying planes and used when forced landings became necessary. A number of flares were designed and tested before a satisfactory type was developed. Type III which is now in use by the Air Service and Air Mail Service is considered an absolute necessity in night flying. Information available is to the effect that fifteen pilots and planes have been saved by the use of these flares when forced to land at night. This flare functions about 100 feet below the plane and burns for 3 minutes with a candle power of about 325,000. Although the present type is satisfactory in operation it is not waterproof and development work is being carried on to perfect a more durable and waterproof type.

The Air Service has very recently requested that a new type of flare be developed for illuminating bomb targets. The requirements are rather severe, but it is felt that they can be met, and work is being initiated on a design of a flare to fulfill the request.

In addition to the work on the major items of pyrotechnic materials a number of other developments have been undertaken and are in various stages of progress. These include a pyrotechnic composition for use in illuminating projectiles in which the Navy is interested, development of a tracer for the 37-mm. antiaircraft gun, a test quantity of flares and signal cartridges for the Air Mail Service and a wind direction signal for the Air Service. This latter signal is a recent development to be used by high speed planes for determining the direction of the surface wind on landing fields where wind direction indicators are not provided. It is necessary to know the wind direction on the ground when landing high speed planes, otherwise a considerable hazard is encountered. A quantity of these wind direction signals are now being manufactured for test by the Air Service. Future development of the signals will be to make a signal which is also visible at night.

The raw materials required in the making of pyrotechnics are quite numerous and varied, but the number of chemicals which may be used to produce satisfactory colors and lights is rather limited at the present time. It is hoped that this number can be increased by further research and experimental work. Other materials necessary are silk, linen, felt, sulphur, charcoal, nitrates, cotton, alcohol, resin, aluminum, steel, paper and brass. These are taken and combined into complete rounds and into means of projecting these complete rounds, the pyrotechnic unit being the only section of the Ordnance Department which develops both ammunition and projectors therefor.

It should not be forgotten that in the beginning of this article it was stated that pyrotechny is an art. This means that it has not reached the stage of a science and, therefore, more experimental and development work is necessary to produce a new and different signal than would be necessary in producing a new piece of material of a kind governed by more exact and plentiful data. As additional data and information become available, pyrotechnics will progress toward the standardization possible in scientific subjects.

Pyrotechnic problems will be solved and difficulties overcome in time, and signals will be standardized as to shade of color, range of visibility and other characteristics. This, however, means much painstaking experimental work with the photometer, colorimeter and spectrograph, and many tests under service conditions. Though these and other problems remain unsolved and new problems may present themselves as work progresses, it is felt that satisfactory progress has been made since the war in the development of pyrotechnic material.

Fuzes

Modern Requirements and the Type of Organization Necessary for Fuze Development Work

H. M. Brayton

A FUZE, as the word is used in Ordnance parlance, has been defined as a mechanism which will cause the missile to which it is assembled to explode at the time or place desired. It was necessary, therefore, to use a fuze in the first explosive missile ever thrown. As time passed and the art of warfare became more and more complicated due to the application of science and engineering it was necessary to develop fuze mechanisms to meet each new condition. The history of fuze development shows quite regular progress ever since the first use of the hollow cast iron shot which was filled with black powder. As the weapons from which the missiles were thrown became more intricate, and as the tactical requirements of modern warfare demanded special actions, it became necessary to resort to intricate fuze mechanisms to obtain the desired results.

Thus we find at the present time that the design of fuzes requires the application of as much mechanical ingenuity together with a good knowledge of engineering and scientific principles as does the design of most any other mechanical device. The fuze designer occupies a very unique position—and incidentally rather a difficult one—as compared with other designers. When the designer of a new machine tool or an air compressor has a model made and tested he can observe its action determining whether or not it works properly, and if it does not function as he intended it is easy to see what is wrong and steps can then be taken to correct the trouble. Such a procedure is not possible in the development of a fuze. The designer carefully works out the design which he thinks will meet the requirements, makes the drawings and then has several samples made. After assuring himself of its safety when loaded he proceeds to test his mechanism under the conditions of service. In the case of an artillery fuze this means fire it from a cannon. If it fails to function as the designer intended, what is he going to do about it? The mechanism is no longer available, having been fired, and generally it is not possible or safe to recover it. He can only guess why the mechanism failed and proceed to assemble another one incorporating the changes which his assumptions regarding the failure indicate. The assumption may be wrong and failure again result. Nevertheless the designer must not become discouraged even with repeated failures.

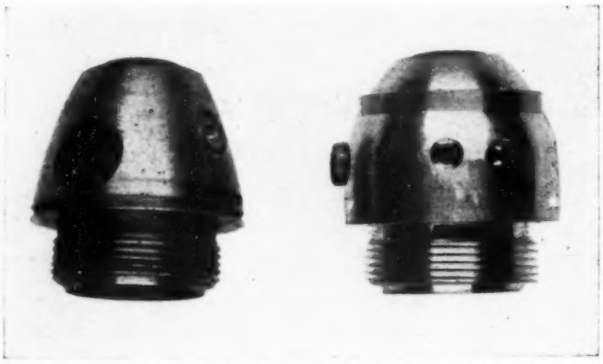
Design of a Bore-safe Combination Superquick and Short Delay Point Detonating Fuze for Artillery Projectiles. The gunner can obtain either action by hand setting.

During the years of fuze development work which have now been carried out the designers have gradually accumulated ways and means of getting a line on why a fuze fails. Some of the methods employed are applicable only to certain types of mechanisms. Each test conducted with the idea of obtaining information regarding the cause of failure must be carefully thought out in advance, otherwise the work may be entirely wasted. In the case of impact fuzes it is sometimes possible to fire them into a sand butt for recovery and thus determine the cause of failure. For such a test the mechanism should be loaded practically inert. This test is very limited in its usefulness because it does not test the explosive train, it does not simulate graze action nor the various kinds of impact, and it has been found that in small caliber of shell fired at high velocity the test is of no value because the shell itself breaks up when it strikes the sand. The evidence is thus entirely lost.

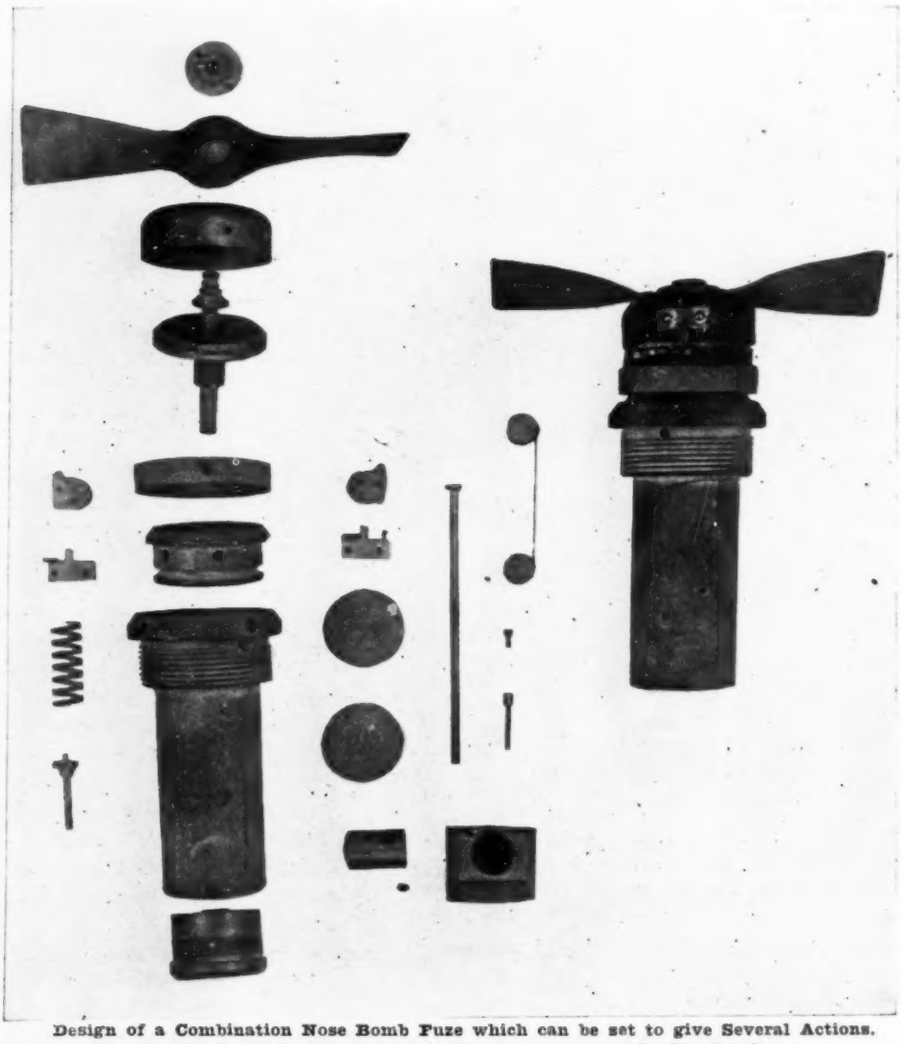
A very interesting problem which fuze engineers were recently required to solve was the determination of the cause of failure of a mechanical time fuze. This fuze contains a clockwork and is designed to explode the projec-

tile a set number of seconds after it leaves the cannon. The first test thought of which might show the cause of failure was to put the fuze inside of a protecting shell and fire it for ground impact at a range where the position of fall could be observed and then recover the fuze for examination. When this was done the designer was surprised to find that his mechanism had run and the fuze, to all appearances, functioned perfectly. When the same type of fuze was fired for air burst it failed. A little study revealed the reason for the apparently contradictory results. When fired in the protected shell for recovery the fuze had not run in flight but had run down only after the shell had come to rest in the ground, so that when recovered some time later it appeared to have functioned correctly.

Two methods have been found quite successful in determining the cause of failures in mechanical time fuzes. One method is to locate the defective part by a process of elimination. One part after another can be removed from the fuze until functioning does occur. If every part except the main spring and gear train are removed and the fuze still fails it is evident that the spring is not strong enough to drive the train under the action of the centrifugal forces. A second method by which the cause of failures in these fuzes can sometimes be located is to fire them under conditions where they will be subjected to various set-back forces and rotational speeds. For example, if it is suspected that the rotation is too high for the fuze, fire some in projectiles having a lower rotation. Such tests must be carefully planned, otherwise one will get into trouble with some of the other features such as a reduction in the set-back to the point where failure of the safety devices occurs.



Two Types of Bore Safe Supersensitive Superquick Point Detonating Fuze for Minor Caliber Artillery Projectiles. The fuzes will function on very light targets such as the cloth wing of an airplane.



Design of a Combination Nose Bomb Fuze which can be set to give Several Actions. It can also be Dropped "Safe," if Necessary, over Friendly Territory.

Prior to the World War, the principal need for fuzes was in artillery ammunition. Since the advent of the airplane the art of bombing has been rapidly developed and fuzes are needed for bombs. The late war also showed the need for many new types of fuze mechanisms not only for artillery and bombs but also for grenades and pyrotechnic devices. Modern fuze requirements are, therefore, considerably more diversified than they were prior to 1914. The field of the fuze designer has thus been greatly enlarged.

As the tactical situations likely to be encountered in modern warfare require a wide variety of artillery weapons not only involving caliber ranging from 37-mm. to 16-inch but also different types of the same caliber, it is evident that the ammunition supply problem looms large. It should be the designer's aim to standardize the units in the various complete rounds of ammunition as much as possible without

Design of a Non-Delay Bore Safe Base Detonating Fuze for Use in Minor Caliber Armor-Piercing Projectiles.

impairing their efficiency. Not only do we need more than one type of projectile in several of the calibers but sometimes several types of fuzes for each projectile. If we were to design a different fuze for every caliber to meet each of the tactical needs the supply problem would be next to impossible to meet.

In the past it has been necessary to assemble the fuze to the projectile at the point of immediate use as it was considered too dangerous a procedure to transport fuzed ammunition. Obviously it is very difficult under war conditions to insure receipt of both the fuzes and the other parts of the complete round at the position required and at the same time when the troops need them. The work of assembly at the gun is certain at times to delay firing.

It is the policy at the present time to so design all fuzes that it will be safe to assemble them to the projectile in the loading plant and ship the complete round. This procedure greatly simplifies the transportation problem and makes it unnecessary for the gunner to do any work on the ammunition except to set the fuze.

The tendency at the present time in fuze design is to combine all the desired actions in one fuze and so design the fuze that it will function in as many different calibers as possible. The gunner then sets the fuze by hand to give the type of action which he desires to obtain to meet the particular tactical requirement.

This same idea of standardization is also being applied to bomb fuzes. The bomber probably has to meet as wide a variety of tactical requirements as the artilleryman and he also desires to have the number of different types of fuzes which he must handle as small as possible.

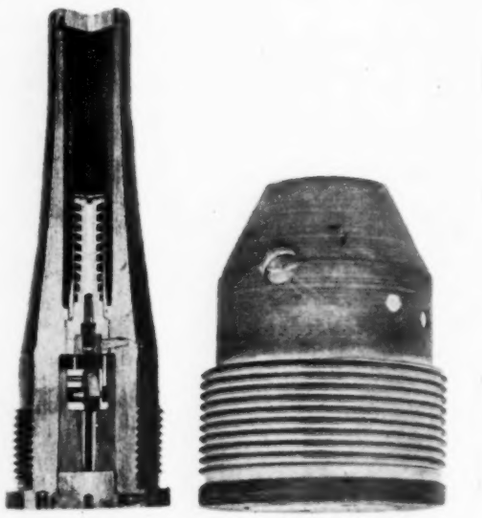
There is, however, another side to this subject of fuze standardization. The more actions required of a fuze the heavier, more complicated and more costly it becomes. It means that a mechanism is being used which will do more than is required of each individual shot. This represents wasted effort. It means that manufacturing facilities will be used in time of war to make things which actually accomplish nothing in the way of enemy destruction. It is, indeed, a very difficult problem to decide whether it is better to use a single purpose fuze or a combination fuze. With the former the supply problem becomes serious, and in the latter the manufacturing problem is the greater. It is probably better policy to simplify the supply problem and burden the manufacturing facilities provided the factories of the country can handle it without disproportionate effort.

Let us now consider some of the technical requirements which the fuze designer must meet to produce these almost universal combination fuzes. The cannon in which the

Design of a Combination Tail Bomb Fuze which can be set to give Several Actions. It too can be dropped "Safe," if Necessary, over Friendly Territory.

fuze will be used may vary in caliber over a wide range such as from the 1.8-inch to the 12-inch. The muzzle velocity may vary from 300 ft. seconds to perhaps 3000 ft. seconds. The maximum pressure may run from a few thousand pounds per square inch to 40,000 lbs. per sq. inch. Some of the projectiles in which the fuze will be used will have an angular velocity of perhaps only 1600 r. p. m. (revolutions per minute), while others will have a rotation of 25,000 r. p. m. and perhaps higher. Not only must the fuze function when used under this wide variety of cannon conditions but also when subjected to many different kinds of impacts including water and armor plate.

The fuze designer is again faced with an unusual condition with which other mechanical designers are generally not bothered. A fuze usually contains high explosive and a sufficient quantity of it to kill or seriously injure a person unfortunate enough to be close by when it explodes. For this reason the design must be arranged so that the danger of a premature explosion in handling or while in the bore of the cannon is reduced to the very minimum. If a fuze fails to remain intact in transportation it may mean a very serious explosion.



Two Types of Short Delay Major Caliber Base Detonating Fuze for use in Armor-Piercing Projectiles.

It will be realized from all of the conditions and requirements which a fuze must satisfy that to develop one to meet new specifications is a problem which is not solved in a short period of time. Even with a well systematized organization it generally takes several years to perfect a new design to the point of acceptance by the using service. In the course of the development many difficulties will be met and must be overcome or the design passes into the discard. Usually many designs must be tried before one is found which meets all the requirements. It may happen that some of the requirements are conflicting, in which case a compromise is necessary, and the using service has to decide which features they desire to retain.

It may be of interest to discuss briefly the various stages in the development of a fuze mechanism from the time the requirements are laid down until it is finally adopted for manufacture and issue to the using service.

The first step is to make a drawing board study to determine the space limitations in the various shell for which the fuze is desired. This point having been determined, the designer works on his problem endeavoring to devise various mechanical combinations which will go into the space which he has, which will function as desired and which will be safe. The various ideas are laid out as an assembly study on the drawing board. Here they are studied from every possible angle. Each part must be capable of quantity manufacture preferably on a punch press, but if this is not possible, then on an automatic screw machine. Slow machining operations such as drilling, milling, shaping, etc., are avoided. The design is studied very carefully in regard to its safety. The loading features and the explosive train must be laid down as nearly in accordance with known good practice as possible. It usually takes several months to evolve a reasonably satisfactory design of fuze and even then there are always many unknown features which can only be tested after sample fuzes have been made.

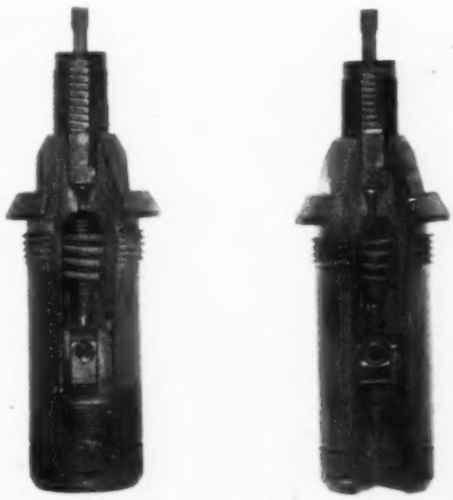
When the design has finally reached the point where it apparently meets the requirements, detail drawings of all the parts are made and orders placed with the shop organization to manufacture a small number. In case the cost of tools for the manufacture of the first fuzes is going to be very high it may be decided to make but one model first by hand methods to further study the design. The various doubtful features may also be tried out in a preliminary way by improvised methods before elaborate tools are fabricated. The particular procedure followed depends upon the nature of the design.

As soon as a few sample fuzes are available the engineer in charge of the development specifies various static tests designed to determine whether or not the mechanism will perform as intended. This will include assembly studies and a search for any unsafe features. After the assembly studies have indicated that the fuze is satisfactory one of the assembled units without explosive is subjected to tests designed to simulate the worst conditions in transportation and handling. There are three such tests carried out at the present time, namely, the jolting, jumbling and drop tests. In the former the fuze is mounted on the end of a long heavy arm which rises and drops suddenly on a heavy base through a distance of about six inches. The jumbling test consists of placing the fuze inside of a box and then rotating the box about its diagonal corners at the rate of about thirty revolutions per minute. The drop test consists of dropping the fuze in various positions from different heights to determine what will happen if it is accidentally dropped in handling. The length of time allowed in these tests depends upon the judgment of the engineer, but in general about two hours in both the jolt and jumble tests are considered sufficient. Any mechanism to be satisfactory should stand repeated drops from a height of ten feet.

When the mechanism has satisfactorily withstood these safety tests it is tested for arming, that is, the designer must know whether or not his fuze will change from the safe condition to the position in which it will explode when fired from the cannon. If the fuze contains a centrifugally operated device it must be rotated about its axis

to determine the angular velocity at which it will arm. If set back or inertia locking means are used which depend upon the linear acceleration of the projectile these must be tested by measuring the force parallel to the axis of the fuze which will arm them. This force should not be more than one-half the lowest set-back found in any cannon from which the fuze will be fired. This considers that the set-back will be calculated using the maximum pressure obtained with the minimum propelling charge in that particular weapon.

After it has been determined that the various locking means should function, the fuze is ready to be tested statically with explosive contents. Most modern fuzes are "bore safe." This term means that the sensitive explosive elements can explode before the fuze is fired from a cannon without setting off the booster or the shell charge. Before a new design of fuzes is fired from a cannon it is necessary to test its bore safe feature if one is used. This is done by completely loading the fuze and then setting off the sensitive elements with the fuze assembled in the safe position. If the booster is not disturbed the design is considered to be bore safe. Usually several fuzes are tested in this way.



Two Designs of a Bore Safe Combination Superquick and Automatic Selective Mechanical Delay Point Detonating Fuze for Artillery Projectiles. Either Action is Obtained by the Gunner by Hand Setting.

It is desirable also before the fuze is fired from a cannon to test out its ability to properly set off the loaded projectile with which it will be used. This is called a static fragmentation test and is carried out in a bomb-proof or sand tub with the fuze armed and assembled to a loaded projectile. The fuze is then fired by any convenient means, being careful to duplicate explosive conditions met with in actual service use.

When the fuze has finally passed successfully all of the above tests it is ready to be fired from the various cannon for which it was designed. If it is an impact fuze preliminary firings are usually made against a wood plank as a target to observe the nature of the functioning obtained. If the results are satisfactory the fuze is ready to be tested under various conditions which may be encountered in service. Such tests can only be carried out where a long range is available. All such firings for the Army are carried out at the Aberdeen Proving Ground. For an impact fuze these firing tests are very extensive as they must cover all of the weapons in which the fuze will be used and the different standard propelling charges for each weapon. They must be tested at different ranges in each cannon and against various targets. The whole idea of these tests should be to duplicate as nearly as possible all of the conditions which the mechanism will be required to meet in actual warfare. Any malfunctioning in these firings such as failures, low order detonations of the shell filler or prematures, are considered very serious, and when these occur the tests are generally stopped until the cause of the trouble is found and corrected.

Once the fuze has passed all of the Proving Ground tests to the satisfaction of the Technical Staff of the Ordnance Department it is ready for service tests. Several thousand are then made and sent to the branch of the Army for which it was designed. When received these fuzes are fired under conditions met with in actual warfare as nearly as possible and a report rendered by a service board together with recommendations regarding future procedure with the design. If the service tests are successful the fuze is ready for acceptance for manufacture and issue to the troops. Such acceptance requires the approval of the Ordnance Committee, the Technical Staff of the Ordnance Department, and the Secretary of War. If not successful then further work must be done to correct the trouble, otherwise the design must be abandoned.

Such, briefly, is the life history of the development of a fuze mechanism from the time the requirements are specified until it is adopted as a standard article for manufacture and issue. Obviously such a development program can not be carried out very rapidly. The conditions to be met are generally too difficult to expect a solution in less than several years from the time the work is first started.

It has been clearly demonstrated that fuze development work can not be successfully carried out without a good, well balanced organization. Any one individual, no matter how good a scientist or engineer he might be, would probably accomplish very little. This condition is probably due to the variety of knowledge and training necessary to solve the problems encountered. Furthermore any one person may find it difficult continually to think up new designs without association with other minds.

Prior to the World War the development of fuzes for our Army was mostly carried out by individual production organizations at our Arsenals. For example, the development of time fuzes was handled by the shop which manufactured them. While this system has certain points in its favor it has others which prevent it from being the ideal method of fuze development. One of the main difficulties lies in the fact that a production and an experimental man have quite different abilities. The necessary qualifications for both are seldom found in one person. A production shop organization generally does not like to be bothered with experimental work.

When this country entered the war in 1917 the Ordnance Department organized at Frankford Arsenal an Experi-

mental Ammunition Department whose duties were to take charge of all mechanical development work on artillery ammunition. Later this Department took over all development work on bomb fuzes.

It was soon found that such an experimental department must have its own shop and testing facilities as it was impossible to get the work done in the production shops when it was urgently needed. It was also evident that the organization should include well trained designing engineers, competent draftsmen, alert testing engineers and a corps of good mechanics.

The war came to an end before many of the things developed by this experimental department could be gotten into production and furnished to the troops in France. The efforts of this Department were not by any means wasted, however, because they not only materially assisted the production departments in the solution of shop problems on ammunition production but also built a sound organization which was capable of carrying on the work of ammunition development after the war.

Instead of disbanding when the war ended, this organization actually expanded and handled more and more development work. This work was entirely of a mechanical nature. At the same time developments were being made in explosives, for use in ammunition, especially at Picatinny Arsenal. As Frankford and Picatinny Arsenals are located so far apart, close cooperation between them was difficult. The result was that the metal parts were sometimes being developed using explosives which were perhaps obsolete while new explosives were perhaps being tested in obsolete metal parts.

The Ordnance Department desiring to correct this situation and consolidate the work on the development of all components of ammunition at one place moved the mechanical development organization from Frankford to Picatinny in 1921.

At Picatinny Arsenal as now organized the aim is not the development of a fuze or of a new explosive but rather the chief purpose is the perfection of complete rounds which will function in the specified cannon as required. It is true, of course, that the fuze has to be developed as a unit but its perfection is carefully coordinated with the other components of the round such as the projectile, cartridge case, propelling powder and explosive charge used as the projectile filler. It is only by such coordination that unnecessary work can be avoided and all concerned in the development of the round as a whole made to realize the necessity of making their part of it fit the parts developed by others.

The staff type of organization at Picatinny Arsenal is now handling the complete round development. On the engineering staff are men who are experts in each phase of the work. The chief of this Technical Staff must direct the efforts of the various members along the lines which will produce a satisfactory complete round. The fuze designer is materially aided by this type of organization, as he thus has available the latest information regarding the proper explosive to use in his mechanism and the types of projectile in which they will be needed.

Very little advance was made in this country in the art of fuze development during the decade prior to the World War in comparison to the strides made in some of the foreign countries. During and since the war, however, much effort has been spent in correcting the backward position in which the war found us. Useful fuze development must be carried out in time of peace as there is not time after war has been declared.

The Army Ordnance Department is developing, during the present period of peace, fuze mechanisms which will function as nearly perfectly as possible, which are safe to transport in the loaded projectile and which can be manufactured in tremendous quantity in the event of war, using facilities which now exist in this country. Such preparedness is the basis of our National Defense.

Army and Navy Club of Philadelphia

THE Army and Navy Club of Philadelphia, located at 313 South Broad Street, was successfully launched with an informal reception tendered by the officers and directors, to the members on Tuesday evening, June 15, 1926. The charter object of the Club is as follows:

"A military organization, in which the members, having served in the armed forces of the United States, or her Allies, during the World's War, may preserve their associations and memories, as well as the traditions of the service, and join with others, who believe in adequate National Defense, in such study of our National History and the science of War, as will fit them to perform their duties as citizens or soldiers in the event of a National Emergency."

The officers of the club are: President, Gen. William G. Price, Jr. (General Price commands the 28th Division, P. N. G.); 1st Vice-Pres., Col. John C. Groome; 2nd Vice-Pres., Maj. Joseph H. Bromley, Jr.; Treasurer, Maj. Edgar S. Gardner; and Secretary, Col. Edgar J. Pershing.

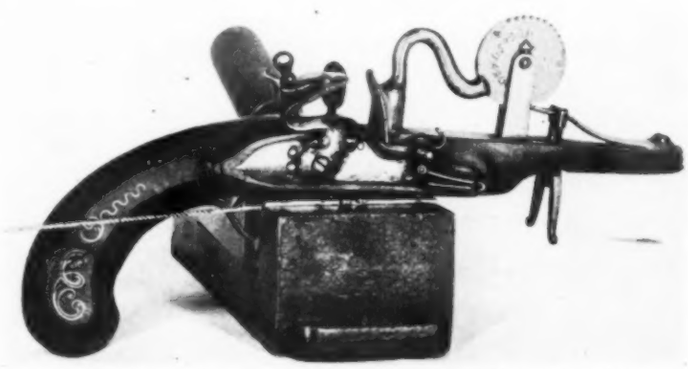
Officers of the regular establishments, when visiting Philadelphia are invited to identify themselves and receive guest cards. The club service consists of reading rooms, lounge, dining room, billiards, and pool room, and an Information Bureau through which it hopes to facilitate service and ex-service men in procuring suitable accommodations for residence in the city. A limited number of bedrooms are available in the club house upon reservation.

Safety In Explosives Plants

H. S. Deck

DURING the World War a large number of people were engaged in work related to the explosives industry, all of whom, and it includes many readers of ARMY ORDNANCE, will for a long time retain an interest in military explosives and in steps toward safer methods in manufacture and handling. To the large majority the thought of safety rules in explosives plants brings to mind nothing but visions of mottos, "Prepare to meet thy God," "All ye who enter here leave hope behind." It is with no thought of disabusing the minds of the latter that this article is written, but rather to discuss in a general way the trend of safety engineering in the modern explosives plant, particularly at Picatinny Arsenal.

It is proposed to limit this article to that part of the industry which deals directly with the dangers due to explosives, describing existing safety methods, suggesting ways and means of further improving them. The safety conditions in maintenance shops, container factories, power plants and other non-explosives buildings are problems common to industry in general and differ from those in explosives plants only in this: employees in explosives plants who are accustomed to work under the continual strain due to unseen hazards look lightly on visible dangers and unsafe practices.



Flint Lock Powder Testing Device for Determining Sparking Properties of Engineering Materials and the Ignition of Explosives by Spark.

In the field of industrial safety, explosives manufacture stands out clearly from other industries in the progress it has made during the past decades. This progress is great by comparison, because the nature of the product has isolated both the explosives plant and the employee. Among the plant employees this isolation has maintained a guild spirit similar to that which controlled industry some centuries ago, in which traditions, not always the best, have controlled. This plant isolation has been maintained, but personnel isolation has largely disappeared with the improvement in transportation facilities. These changes have taken place within the memory of men who are still actively engaged in the industry.

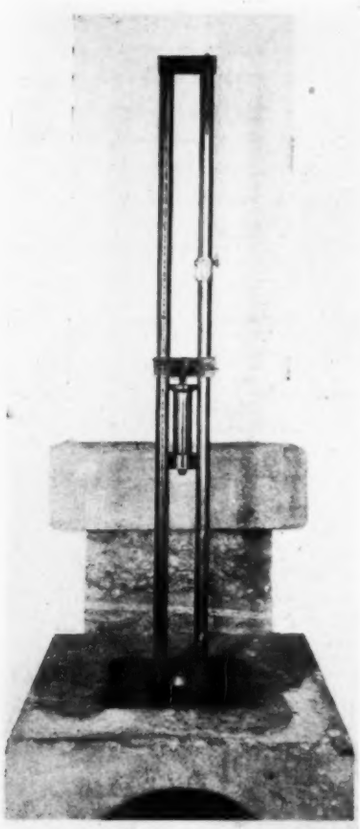
There are a number of causes that have brought about progress in safety conditions. The first is humanitarian: it is recognized that everything must be secondary to the protection of life and limb; all popular agitations for safer working conditions have their origin in this. The second is economic: there is no branch of industry in which safety is of so great an interest to both capital and labor. Other causes and influences are: parallel work in other industries; state laws with periodic inspection by the State Department of Labor; employers' liability; unconscious competition within the industry, that is, between plants and between companies; better equipment, in the design of which calculations have replaced tradition.

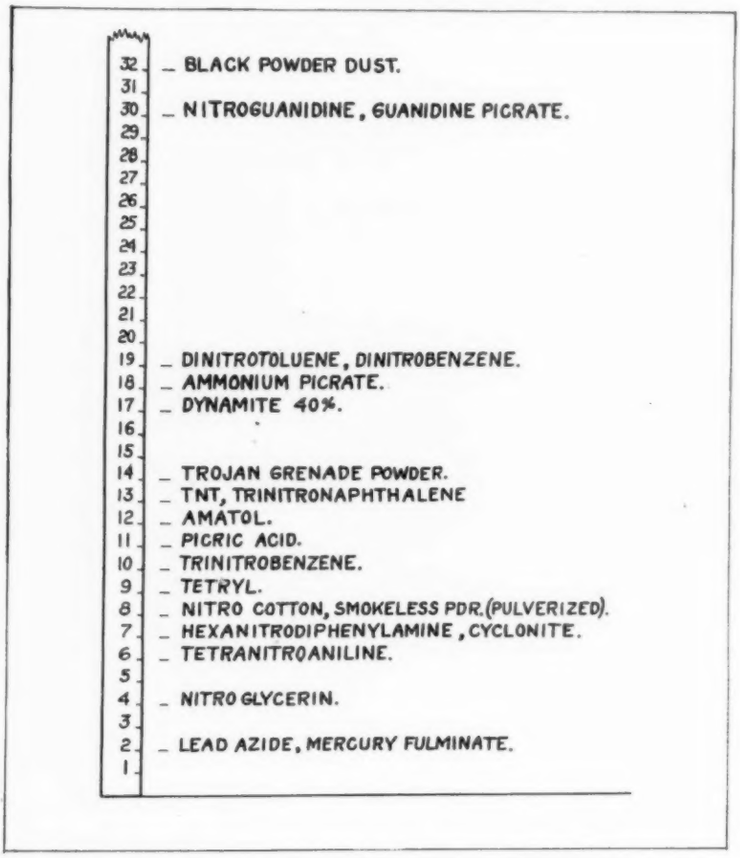
In effecting these results the plant organizations have been aided by accident investigating boards, inter-company committees, and the pioneer work done by the Bureau of Mines, the Bureau for the Safe Transportation of Explosives, and other agencies. The value of the work of investigating boards has not always been in the discoveries made or in the logical conclusions and recommendations of the boards but rather in the psychological effect produced. In these investigations operators have had an opportunity for expression of opinions, unwholesome conditions have been brought to light, and unsafe practices eliminated. The cooperative work of inter-company committees has been particularly beneficial. An illustration of the work done by such a committee is the report of a "Committee of Manufacturers of Powder and High Explosives of the United States" published as the "American Table of Distances." From the records of explosions kept by individuals and explosives companies in America and with such other information as could be obtained from Europe this committee was able to determine the approximate distances beyond which explosions of a given weight of explosive would do no material damage to buildings. This work has been supplemented by fixing a safe distance between explosives buildings and public highways or railroads. These changes have not been brought about without heartaches; the industry has called for the pioneer and individualistic type of men, types to whom collaboration was frequently distasteful. The value of this information to explosives plant designers in the stress of war conditions cannot be over-estimated.

Efforts toward greater safety usually find expression in rules, regulations and laws; in many instances these go so far as to specify the manufacturing processes to be used. All such regulations of necessity have their root in experience; the broader the experience the more valuable the rules will be.

It is evident that in all our efforts toward greater safety we are making progress only through misfortune; our

methods are directed principally toward preventing repetition of accidents rather than in attempting to forestall them. In any effort to study safety conditions or to design equipment and improve processes with a view to greater safety we are faced by the lack of basic information in some very important particulars concerning both explosives and engineering materials. Take for example black powder dust, our oldest explosive, of which about two hundred million pounds are made each year in the United States; can it be ignited by a friction blow or a static spark of the maximum intensity to which it will be subjected in the manufacturing or loading processes? Can TNT dust or molten TNT be ignited under similar conditions? What are the characteristics of engineering materials that affect ignition? It is considered essential to better safety conditions in explosives plants that basic information concerning the characteristics of the explosives and of engineering materials be obtained.




32 – BLACK POWDER DUST.
30 – NITROGUANIDINE, GUANIDINE PICRATE.
19 – DINITROTOLUENE, DINITROBENZENE.
18 – AMMONIUM PICRATE.
17 – DYNAMITE 40%.
14 – TROJAN GRENADE POWDER.
13 – TNT, TRINITRONAPHTHALENE
12 – AMATOL.
11 – PICRIC ACID.
10 – TRINITROBENZENE.
9 – TETRYL.
8 – NITRO COTTON, SMOKELESS PDR.(PULVERIZED).
7 – HEXANITRODIPHENYLAMINE, CYCLONITE.
6 – TETRANITROANILINE.
4 – NITRO GLYCERIN.
2 – LEAD AZIDE, MERCURY FULMINATE.

Left: Drop Test Machine at Picatinny Arsenal Used to Determine the Comparative Sensitivity of Explosives to Hammer Blow. Right: Chart Showing the Height of Fall in inches of a 2-kilogram weight Required to Ignite Explosives as Determined by this Apparatus.

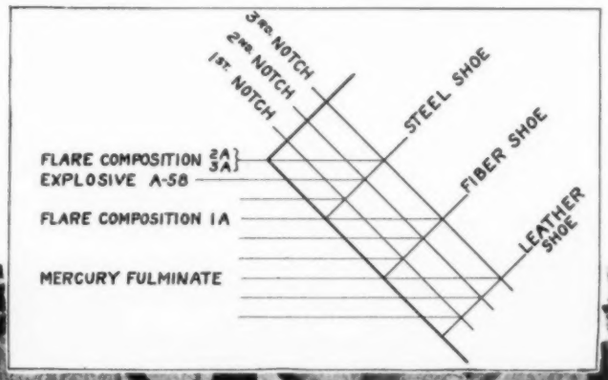
In the work which Picatinny Arsenal is doing in the development of explosives and explosives mixtures the need for such data has been recognized and equipment is being designed or adopted to carry out the necessary investigations. The following is a brief description of the equipment in use or proposed for this purpose.

For testing ignition of various explosives by friction blow a friction pendulum machine similar to that used by the Bureau of Mines at Bruceton, Pennsylvania, is being used. Some modifications of this equipment are being made, the principal of which is the introduction of an attachment for controlling the temperature of the test sample; this will make possible tests on TNT or amatol in a molten condition. In this test a 20 gram sample of the explosive to be tested is placed on the base or anvil and the shoe attached to the pendulum is swung back and forth over the base striking a friction blow on the explosive with each swing. The holders for the base and shoe are designed to take coverings of various materials such as steel and hard fibre. The intensity of the friction between the shoe and the base is regulated by adjusting the pendulum length. The uniformity of friction is obtained by adjusting the pendulum length by trial before each group of tests until the pendulum makes a fixed number of oscillations before coming to rest. This is a severe test but fails to ignite the majority of our military explosives.

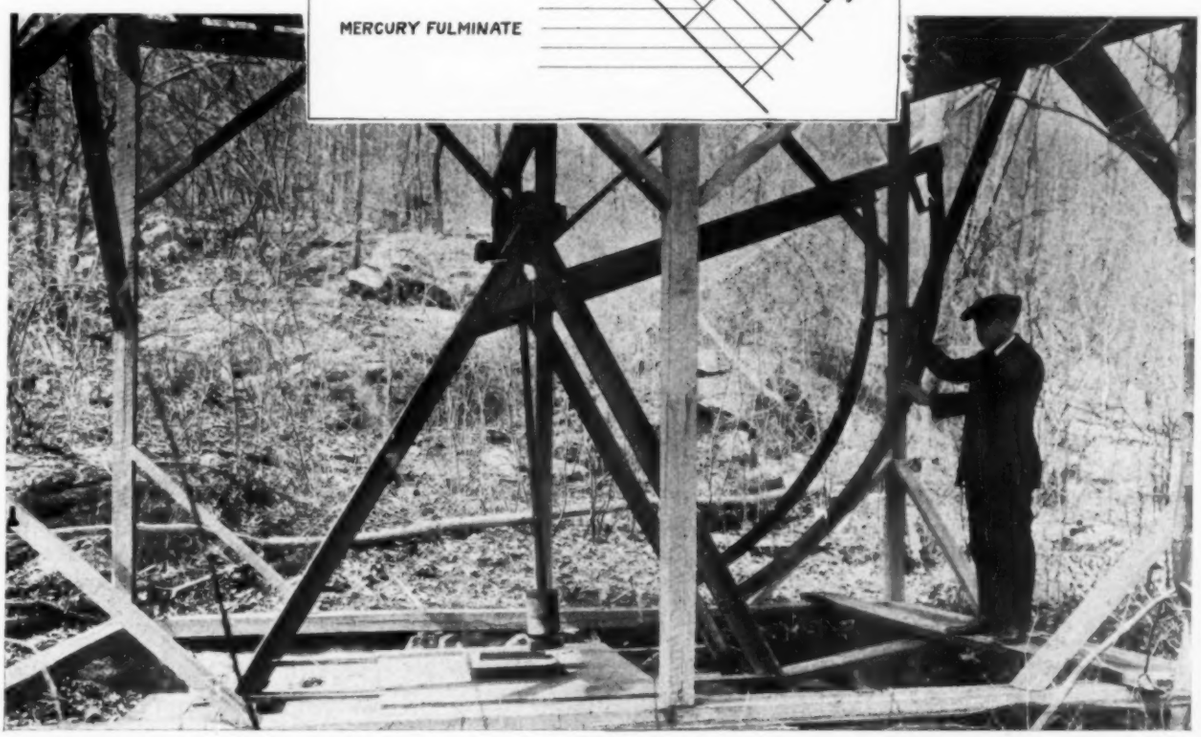
To determine the ignition properties or sensitivity of explosives to hammer blow or impact, the drop test machine is used. For many years this machine has been an accepted piece of equipment in the explosives laboratory and the records are directly applicable to our program. In operation it is comparable to a pile driver; the explosive is inclosed in a copper capsule and set on the base of an anvil and a two kilogram weight is dropped upon it from an adjustable height. The minimum height of drop required to explode the sample is taken as the relative sensitivity of the explosive. This test has been made on practically all of the explosives in which Picatinny Arsenal

has been interested. The density of the test sample, the size and shape of crystals and the temperature of the test piece are recognized as conditions which affect the results and concerning which much work remains to be done.

For testing the sparking properties of metals and the ignition properties of explosives by spark, a modification of a flint-lock mechanism is proposed. When testing for sparking properties a standard ignition mixture easily ignited by spark, such as black powder dust, is placed in the pan, and a test piece of the material is clamped in the hammer; failure to ignite the black powder dust in repeated trials classes the material as non-sparking. Monel-metal, Alcumite, Everdur, and special bronzes have been tested by this method and classified. In the limited number of tests that have been made it is found that some materials from which no visible spark can be obtained will ignite the black powder dust. When explosives are being tested for ignition by spark a standard special quality and form of flint is placed in the hammer and the explosives test sample is placed in the pan. In this test as in the preceding, the data are comparative. We find for example, that TNT and tetryl cannot be ignited by a spark that will invariably ignite black powder and that certain airplane flare mixtures can be ignited by such spark when conditions of the trial are favorable. Work with this test has been very instructive, it has not gone far enough, however, to be considered as established. A fire-proof, non-sparking floor covering has been developed under this test. This equipment has its limitations, and it is of interest as pointing the way to the goal; it has given us an additional view on the characteristics of explosives.

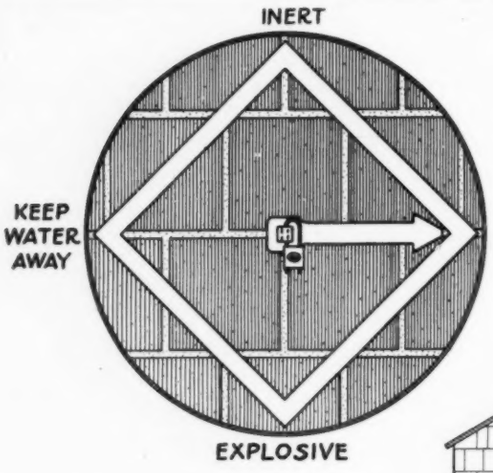


Safety work on static electricity has been confined principally to the elimination of static charges. Little is recorded of the static charge required to ignite various explosives or process mixtures and materials, and even less of the origin of such static charges. It is probable that much work which is now being done in the elimination of static charges is unnecessary for the reason that in the majority of instances there is no danger of ignition involved. Tests with mechanical equipment are required to show the maximum static charge that can be produced and accumulated under plant conditions for comparison with the minimum charge that will ignite the explosive. With manufacturing processes, particularly where a highly inflammable solvent or explosive is involved, such as the recovery of solvent in the drying of smokeless powder, extensive studies are required to furnish data for the development of safer processes and for the design of fool-proof equipment. In such evaporation, drying, or solvent recovery processes, the static is not the popularly conceived frictional static charge, but is that produced by or due to the solvent or moisture leaving the process material and must be studied from a new angle.



Friction Pendulum Machine at Picatinny Arsenal used in The Greater Safety Program for Testing Ignition of Explosives by a Friction Blow. Above: Chart Showing Relative Ignition of Explosives by Friction Blow as Determined by this Apparatus.

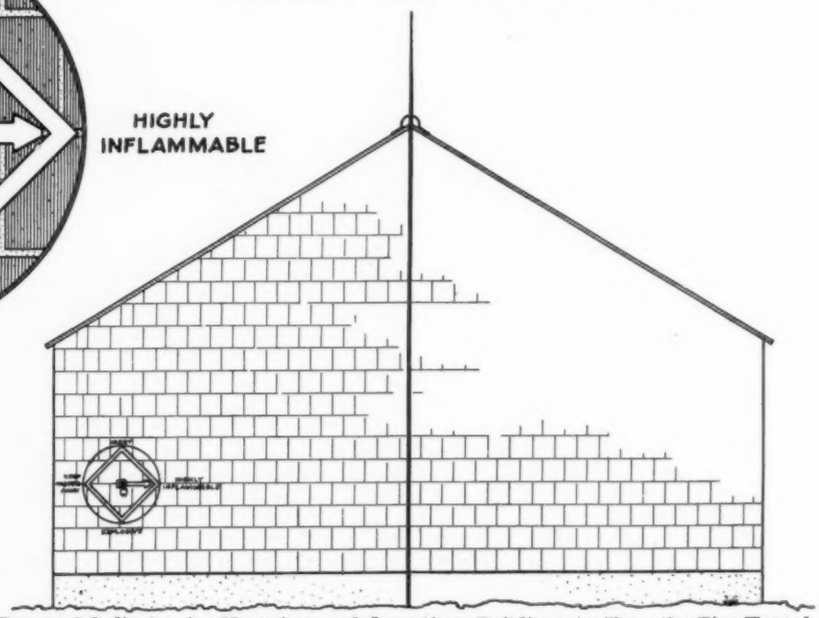
The machining of explosives is an important part of loading operations; it consists principally in drilling, bor-



ing and facing pressed TNT, amatol, ammonium picrate and other pressed and cast explosives. Because of long practice these operations are accepted as safe; however, there are many phases in connection with these operations about which basic information should be our stock in trade, such as for example: the best material for the cutting tools where sparks are a hazard; safe cutting speeds; the most effective rate of feed or depth of cut, and the shape or grinding of the cutting edge. It is important not only to have these data about explosives which have been used and about which there is an established practice, but it is particularly important to have them concerning new explosives and explosives mixtures while the explosives are in the experimental stage and before the development work begins. The equipment which has been adapted to obtain this information by trial is a specially designed power drill. The explosives sample and the cutting tool are surrounded by a steel plate or shield for the protection of personnel and for the recovery of parts for examination in case of an explosion. To obtain the maximum safe speeds it is proposed to increase the cutting speeds until ignition of the explosive marks the danger point or until a speed sufficiently above the desired speed is obtained that will provide an acceptable factor of safety. By introducing foreign materials in the explsives test samples, it can similarly be shown that certain metals make safer cutting tools than others. Endurance tests will be run to show the ability of the cutting tool to hold a cutting edge and to note the comparative heating of the various kinds and shapes of cutters. Temperature control accessories are being made for conducting this work under various temperatures of the test piece.

Safety in pressing explosives is assumed, probably because of the relatively small number of accidents in this class of work. However, there are certain phases in connection with this process that are under suspicion. Such are: the repressing of ammonium picrate, the use of high pressures in mercury fulminate loading. No new equipment is required to carry out this investigation; tests in which pressing is carried on under conditions sufficiently severe to show that the normal process provides an approved margin of safety will establish safe practice.

It is proposed to place these data in the hands of designers of equipment and processes, safety boards, executives and operators to enable them to proceed in their work with a confidence that has been lacking; this cannot fail to be beneficial in showing the way toward the elimination of unsafe practices.



Proposed Indicator for Magazines and Operations Buildings to Show the Fire Hazard.

Much of the information now recorded on explosives has no bearing on the problem of safety. From a safety standpoint we are not primarily concerned with rates of detonation, temperatures of explosion, or volume of gas formed, and from the present indication in so far as most explosives are concerned, it remains to be shown that the temperatures of ignition have a direct bearing on the safety problems. It is for example obvious that when the rate of detonation or the brisance of an explosive enters into an accident, safety rules and regulations or preventative measures are no longer of interest. In other words we are primarily interested in preventing the ignition of the explosive rather than in the violence of the explosion. Our interest in brisance is secondary and limited to those installations or processes where shields or barricades can be of service. This is a field in which there appears to be opportunity for improvement. It is possible that steel shields give the operator a feeling of security somewhat out of proportion to the protection they afford. It is thought that a fire resistant shock absorbing material would be a more suitable type of material for this work. With this in view Picatinny Arsenal has made trial installations of protecting screens of woven rope, asbestos blocks and similar materials.

There are some conditions attending explosions and fire fighting in explosives plants not common to the accepted practice. When dealing with explosives of certain types, fire fighting equipment other than automatic is not only not required but undesirable. Under these conditions personal safety is the only consideration and any equipment which might tempt the operators to combat a fire must be kept away.

The following equipment is suggested for use in plants

where conditions require; on rare occasions their need is brought to our attention in a forceful way:

In plants operating on loaded projectiles there should be some place of refuge in which personnel can find shelter from the unescapable shower of projectiles and fragments resulting from a major explosion. Bomb proofs or dugouts with some simple equipment and first aid supplies would fill this need.

There are instances in fire fighting when a vantage point must be abandoned because of an increasing hazard due to the fire, when abandonment means losses and greater hazard. There are others in which a line of hose can be safely established and protection assured but which cannot be maintained because of the approaching danger. For these and similar instances the use of an armored hose-nozzle-setting-device would be of great service. One or more nozzles arranged in the shield of a gun carriage, for example, would fill this requirement and be of great service in maintaining protection at dangerous points without exposing personnel. There have been instances where improvised devices of this kind have been of untold value.

Good practice dictates that experimental and development work involving explosives be carried on in isolated buildings with the least possible number of persons in attendance. In an establishment like Picatinny Arsenal where there is considerable firing and blasting going on there is a chance that a minor explosion will not be noticed and that no alarm will be turned in. Such conditions defeat the main object of our fire fighting organization, namely, that of bringing early relief and extinguishing the fire in its incipient stage. For such conditions an automatic alarm system, in which a fire or explosion in a room or building will automatically operate an ennunciator at the fire department headquarters, will fill a conceived need.

Knowledge of the characteristics of the material in a building is one of the essential requirements for its successful protection in case of fire. There have been innumerable instances in which a fire would have been fought with vigor if the fire fighting force had known that there was no unusual hazard. In depots with hundreds of buildings and continually moving or changing stock it is impossible for the fire fighting force to know the contents or characteristics of materials in a given building. It is suggested that a mark indicating the danger in case of fire be placed on each process or storage building. A grouping of Ordnance materials and explosives from the fire-fighting point of view resolves them into four main classes: (a) materials in which there is no usual hazard; (b) highly inflammable materials but without explosive hazards, such as smokeless powder; (c) explosives; (d) materials on which, in case of fire the addition of water creates an explosive hazard, such as nitrate of soda.

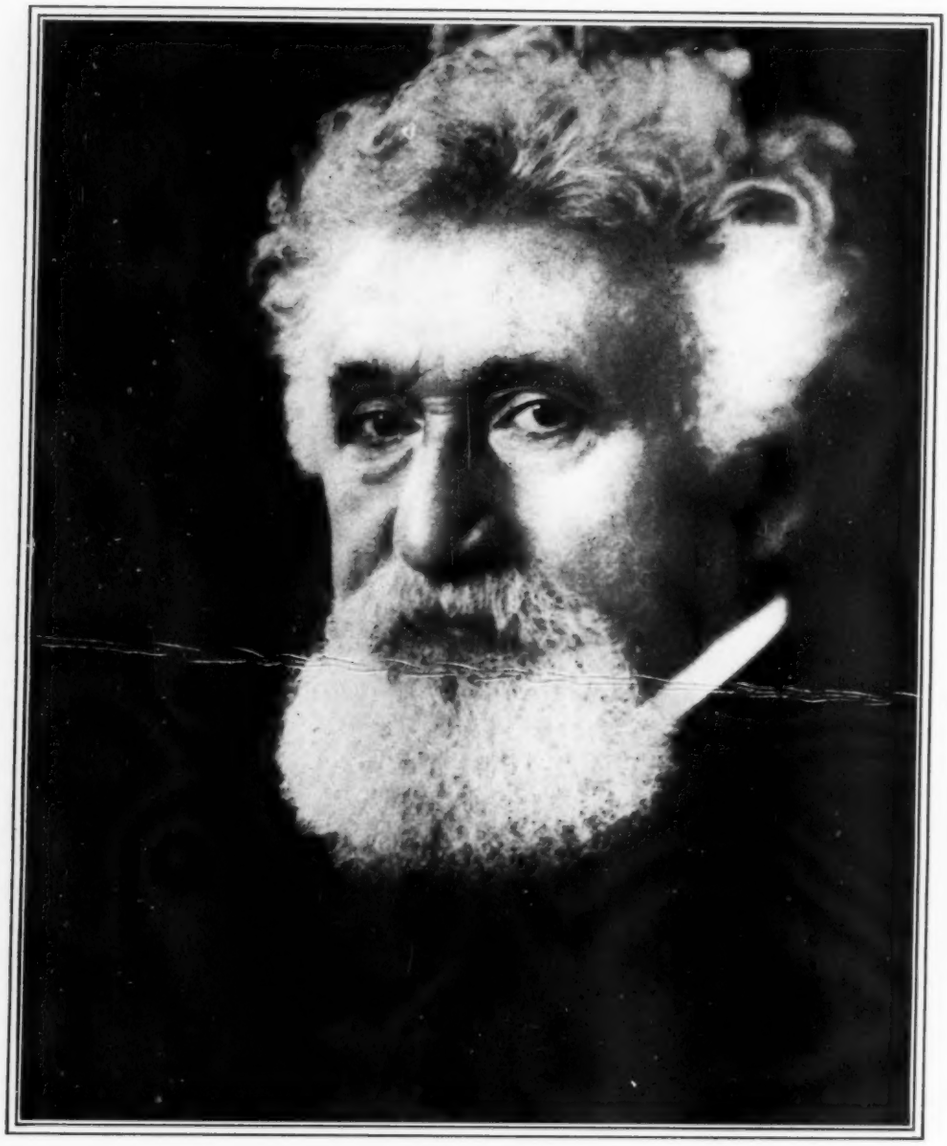
A simple adjustable indicator on the outside of the building will accomplish this object.

There is another class of safety regulations of a more subtle form; a form perhaps easily framed into rules and regulations, which is frequently misunderstood and variously approved and condemned. Such regulations are valued by their effect on plant morale. Under this class come good lighting, barricades, protection against lightning, sanitary appliances and conditions. However important these may be in a non-explosives plant they assume a place of first importance in explosives plants where alertness is a cardinal virtue. Carelessness is a contagious disease of far-reaching consequences, and it follows inevitably that the average individual, when surrounded by safety appliances and high standards grows and lives up to his environment, whereas when working with unsafe equipment under unsanitary conditions he becomes more careless. In the latter instances some other method of instilling the fear of disaster is required. This is well illustrated in the answer of a president and general manager of a large explosives company, a man of large experience, to a director who had the temerity to suggest that steps be taken to reduce the loss of property due to repeated minor process explosions by special preventative measures. His reply in effect was, "We are not trying to reduce the number of these explosions; we need these explosions every little while to keep the men from getting careless." However effective such methods may be they are happily obsolete.

It is probable that no code or set of rules can be written to cover all conditions that may arise in plants engaged in straight production of explosives. At an establishment like Picatinny Arsenal where new processes and materials and new equipment are constantly coming forward some method of supplementing the safety rules or regulations is required. At the present time this need is filled by a board of three appointed by the Commanding Officer and known as the Safety Board. This is in fact a board of review which is required to pass on all new processes, methods and designs before they are used and on all accepted methods and equipment at any time when their safety is brought into question. The operation of this board is a part of the safety organization and procedure, and will not be enlarged on here.

Contrary to popular opinion statistics show that the accidents to employees in modern explosives plants do not compare unfavorably with non-explosives plants. In fact the claim is made that explosives plants operating under the influence of an effective safety organization offer less hazard on the whole than many plants in the non-explosives industries that are commonly considered as being safe.

In the work for greater safety in explosives plants there is a long road to be traveled and there are no terminals in sight; each step toward better safety shows a path to new opportunities for further improvement, "and the end is that a workman shall live to enjoy the fruits of his labor; that his mother shall have the comforts of his arm in her age; that his wife shall not be untimely a widow; that his children shall have a father and that cripples and helpless wrecks who were once strong men shall not longer be a by-product of industry."



Hudson Maxim

Filling Armor-Piercing Projectiles With High Explosive Bursting Charges

A Foreword—by Hudson Maxim

THE very able article, painstakingly truthful and accurate, by Capt. John P. Harris, Ord. Dept., U. S. A., which follows, is deserving of appreciative comment by one of the civilian pioneers, who, more than a quarter of a century ago, undertook, in co-operation with the Ordnance Board of the United States Army, to discover a satisfactory high explosive bursting charge for projectiles.

The Ordnance Board was not satisfied with any of the explosive compounds previously made and tested either here or abroad. It was accepted as an absolutely indispensable desideratum that the high explosive to be selected should be absolutely stable, enabling it to be kept any length of time without deterioration; also that it should be so insensitive to shock as to enable it not only with absolute safety to withstand the shock of discharge from the gun, but also the far greater shock of penetrating heavy armor plate, to be exploded by a detonating fuze, either within the plate itself, or behind the plate, where the destructive effect should be greatest.

TNT (tri-nitro-toluol), while very insensitive, was not found to be sufficiently insensitive exactly to meet requirements as a bursting charge for armor-piercing projectiles. Besides, TNT lacks the high disruptive and shattering force of picric acid and certain picric acid compounds.

Therefore, two compounds of picric acid were selected which had the greatest promise—the one was called Maximite, a compound invented by me, consisting of ninety per cent. picric acid, combined by fusion with ten per cent. of mono-nitro-naphthalin.

I found that when melted picric acid and mono-nitro-naphthalin were combined, an actual mono-nitro-naphthalin picrate was formed, which, although consisting of a somewhat loose chemical union, was nevertheless found, on analysis, to be an actual picrate. This mono-nitro-naphthalin picrate closely equalled the great density and high specific gravity of pure picric acid, while it possessed per unit of weight an explosive force quite comparable with, even if it did not actually equal, pure picric acid, in explosive violence.

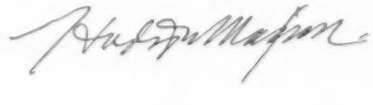
The terrific force of Maximite is well illustrated by the fact that more than 7,000 fragments were recovered from a seven-inch armor-piercing forged steel shell detonated in an explosion chamber. In armor-piercing tests with Maximite, a Harveyized nickel steel plate, twelve inches in thickness and weighing thirty tons, was erected, and supported by heavy timbers, backed up by a huge sand butt. A 12-inch armor-piercing shot, without fuze, containing twenty-three pounds of Maximite, was fired through this plate, and recovered intact from the sand butt, proving the resistance of Maximite to the severest shock.

Another 12-inch armor-piercing shot, also containing twenty-three pounds of Maximite, and armed with a fuze, was fired at the same plate. The fuze acted to explode the projectile when about half way through the plate. Although the quantity of Maximite was but twenty-three pounds, the plate was broken into many pieces, one fragment weighing several tons was hurled to the top of the abutment, and not a piece of the plate remained standing.

The melting point of picric acid was very materially lowered by the 10 per cent. of mono-nitro-naphthalin, greatly lessening the danger in melting for filling shells. The facility, ease and safety with which Maximite could be melted and charged into shells was greatly in its favor. Watchful care, however, had to be exercised, to ensure the elimination of any air spaces in the Maximite charge in the shell, because an air space of any considerable size might allow the explosive to crush back into the space by the shock of discharge, causing a premature explosion.

I found, however, that air spaces could be prevented by the simple method of tamping the charge with a wooden rammer while in the process of filling.

Picrate of ammonia, recommended by Capt. B. W. Dunn, Ord. Dept., U. S. A., and designated Explosive D., was the other picric acid compound tested by the Ordnance Board simultaneously with Maximite. The properties of this compound and the methods employed in charging it into projectiles, together with the method finally adopted at Picatinny Arsenal for charging armor-piercing shells with Maximite, are very accurately and lucidly described in the following article.



Explosive D Loading Plant, Picatinny Arsenal.

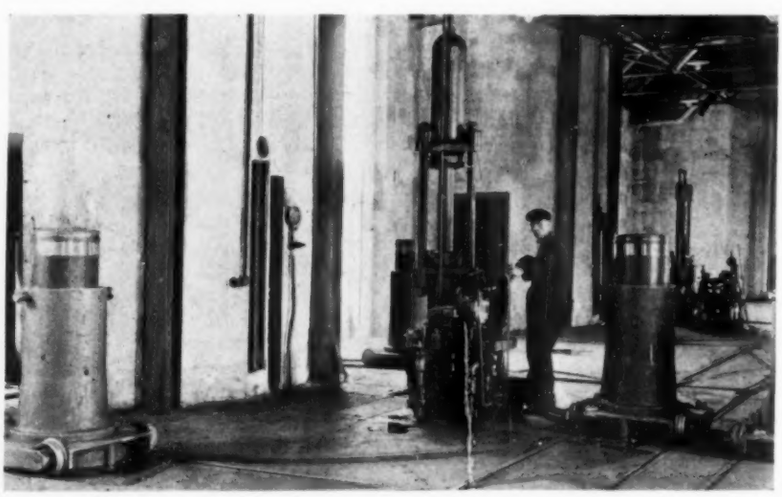
Loading Ammunition at Picatinny Arsenal

Capt. John P. Harris, Ord. Dept., U. S. A.

THE loading of ammunition at Picatinny Arsenal is very readily divided into two phases. The first phase covers loading done prior to July 1, 1919, the second, all loading since that date, as it was at that time the large expansion was started which has developed this arsenal into one of the largest Ordnance stations, as well as one of the most important. In view of this natural division, the loading of ammunition will be considered in the following manner: (I) Loading Work Prior to July 1, 1919; (II) Loading Work Since July 1, 1919.

Loading Prior to July 1, 1919.

About January, 1902, consideration was given to the erection of plants for loading shells at Picatinny Arsenal. On October 31, 1902, an Ordnance Board consisting of Maj. R. Birnie, Ord. Dept., U. S. A., Capt. E. B. Babbitt, Ord. Dept., U. S. A., and Capt. B. W. Dunn, Ord. Dept., U. S. A., reported to the Chief of Ordnance that arrangements for loading maximite could be more quickly installed than for loading explosive D. They recommended that the maximite installation be made at once but suggested that it would be preferable to load at least 50 per cent of the projectiles with explosive D.



Turntable with 16-inch Armor-Piercing Projectiles in Position; Explosive D Loading Plant.

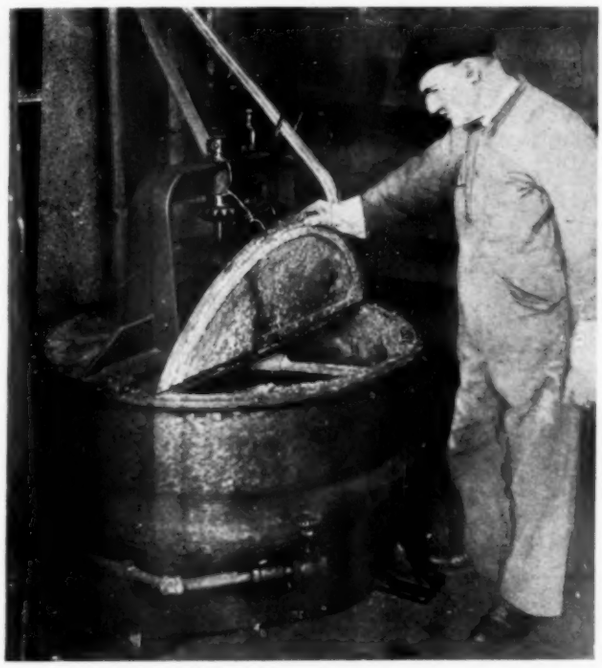
MAXIMITE

Their recommendation for maximite was that a temporary building be erected and equipped with seven kettles, six of a plain pattern with a hand cover only, omitting the fume stack and also the outlet valve at the bottom of the kettle, and one with all appurtenances in accordance with the suggested plan of Mr. Hudson Maxim which called for a porcelain lined steam-jacketed kettle, with a bottom discharge. The board recommended that

this latter kettle be used in an experimental way as a means of testing its practicability for future use. Contracts were awarded for the erection of this small plant in the early part of 1903.

Under date of July 23, 1903, the Chief of Ordnance instructed the Commanding Officer at Picatinny to begin

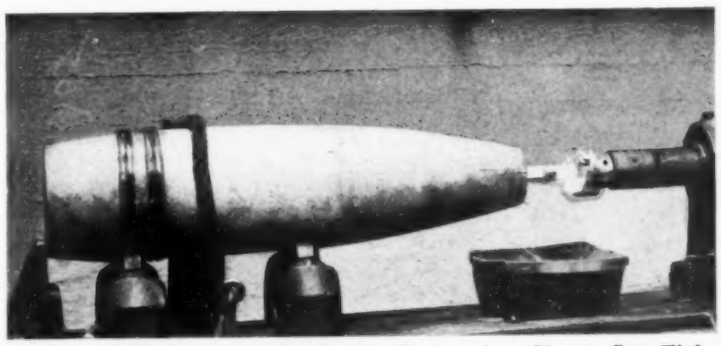
sists mainly of a novel picrate.' Maximite is fusible. Shells are filled by melting it and pouring it into the cavity in the melted state. The Ordnance Board reports that the tests indicate that it is a suitable explosive for armor-piercing shells. It was used in the 12-inch armor-piercing shell in the Gathmann gun trials."



A TNT Melting Kettle at Picatinny.

Pouring TNT into 155-mm. Gun Projectiles at Picatinny.

immediately the filling of shells with maximite. The Commanding Officer advised the Ordnance Office of difficulty in carrying on this work, as follows: "As is known to the Ordnance Office, picric acid is a very disagreeable substance to handle due primarily to its discoloring effects on the skin, its injury to all clothing worn and again to the danger in handling it. In attempting to carry out the instructions of the Ordnance Office this office was much delayed in finding men willing to do the work. Finally on August 14, 1903, consent of five men to undertake the work was obtained and the men were put to work at once."



Drilling out TNT to form the Booster Cavity of a 155-mm. Gun High Explosive Shell.

Maximite was a mixture of 90 per cent picric acid and 10 per cent mono-nitro-naphthalin. The mono-nitro-naphthalin was melted in a kettle and then picric acid was gradually added, with continuous stirring. This mixture was then poured into the shells. In Weaver's book, *Military Explosives*, first edition, the following information on maximite is given. "Mr. Maxim in an article in the *Journal of the Military Service Institution*, November, 1901, gives some account of maximite. He says it 'con-

Notations were made on the records that experience showed 50 pounds steam pressure was insufficient to melt this material within a reasonable time and that 85 to 90 pounds was employed with economy. The period over which maximite was loaded into shells at Picatinny was of short duration, probably not more than two years.

Maximite loading was not successful as considerable difficulty was encountered in endeavoring to obtain a cast free from cavitation.

Due to the cavitation, and prematures resulting from these cavities breaking down when the projectile moved forward in the gun, it was decided to remove this explosive from the shells which had been loaded. The method used in removing maximite was quite different from that which is now used in removing explosives and it is believed a slight reference to it will be of interest. The shell was entirely encased in a steel jacket provided with steam coils. The jacket could be opened at one end to admit the shell. The explosive was not completely melted. The entire shell was heated so that the explosive adjacent to the walls of the cavity of the shell melted first, which freed the cast

and thus allowed the remaining solid part to slide down out of the shell.

Explosive D

During the year 1903 a contract was placed for the erection of a building to house a hydraulic pressing plant for inserting explosive D (ammonium picrate) into armor-piercing shells. In 1905 the contract was placed for the purchase and installation of the machinery to equip this building. Operations in this plant were intermittent but the method remained the same until about 1917 when it was decided that some attempt should be made to keep the ammonium picrate (picric acid was also used in a few tests) from coming into immediate contact with the side walls of the projectile. In order to accomplish this there was developed a method of placing a "TNT surround and seal" within the shell. This surround and seal was made by pouring TNT into the shell, allowing it to stand for a few minutes and then pouring out the TNT which had not solidified, leaving a very thin layer of TNT immediately on the side walls. The explosive D was then pressed into the cavity. This practice, however, was discontinued as it was believed that some prematures were caused due to the breaking down of this surround and seal on set-back and also that TNT would not stand impact on armor plate.

Cutting down Explosive D for Base Plug Assembly. Explosive D Loading Plant, Picatinny Arsenal.

During this period, however, practically all of the armor-piercing shells were loaded at the coast defenses by enlisted men. The explosive D was weighed out into charges of the correct size and was turned over to a soldier who, with a wooden ram and wooden hammer pounded away until all of the explosive was in the shell. This practice was possible as long as the specified density remained 1.33. It is impossible, however, to follow this practice now that the density has been increased.

Propellent Charge Loading

Propellant charge loading was the first real production work done at this arsenal. This operation antedates the Spanish-American War and has been continuous ever since. The first charges loaded contained brown prismatic powder, black powder, or nitro-glycerin powders. With the development of smokeless powder and its use as the military propellant, the plant was converted for loading this powder. The silk bags which were used to contain these powders were as a rule made at the arsenal. In the event of rush orders some of the bags were made in the homes of the people in the immediate vicinity of the arsenal. Women would come to the arsenal, secure cloth, thread, etc., take the material home and sew it on their machines and then return to the arsenal with the completed bags. This practice continued until the World War.

During the early stages of the World War Maj. J. H. Meyers developed a bag wrapping machine which revolutionized the bag loading operations. Prior to this time it was customary to have the bag made considerably larger in diameter than was necessary and then by the use of lacing twine the charge was tightened so as to make it rigid. This bag wrapping machine permitted the bags to be made approximately the exact size required. The charge was then wrapped with putteeing tape about 2 inches in width. This practice used slightly more cloth per charge, but did not prove to be a drawback to the method as it permitted the use of a much lighter grade of silk cloth in the side walls of the bag because of the extra strength given by the tape, which actually worked out as a saving in money. By the use of this machine, production per operator was increased about eight times. It is believed that had not this machine been developed, considerable difficulty would have been encountered in obtaining, first, the production of the laced type silk bags themselves, and secondly, the production required in the number of charges.

TNT and Amatol Loading

When the United States entered the war in 1917 the high explosives for shell filling used in this country were ammonium picrate and trinitrotoluol. Ammonium picrate was used for armor-piercing projectiles and trinitrotoluol was used in all shells for mobile artillery ammunition. The experience of our Allies had already shown us the vast quantities of high explosives necessary for filling shell, trench warfare ammunition and bombs. It was apparent that the supply of TNT available, even after the facilities of the explosives industry had been fully expanded, was insufficient for the needs of our shell-filling program.

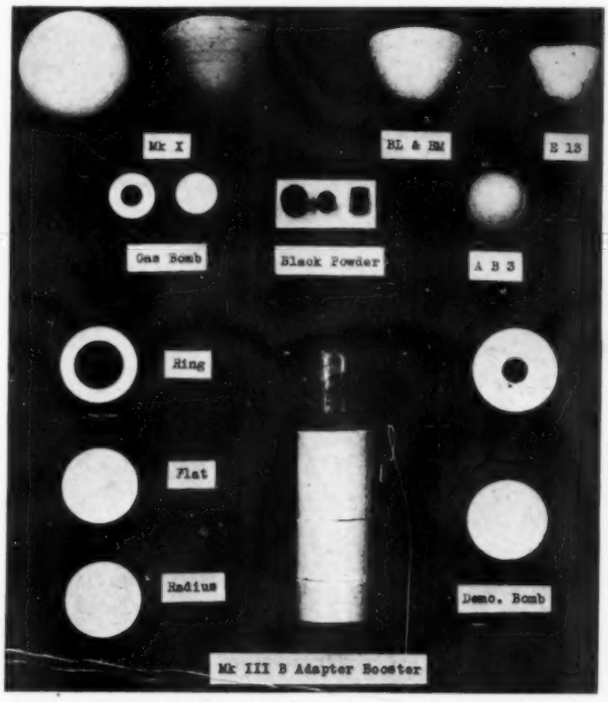
Early in the war England found that it was impossible to secure a sufficient supply of TNT for her needs and after an extended research in the subject of substitute explosives, decided upon the plan of mixing TNT and ammonium nitrate in varying proportions.

Fortunately for this country, England had been using amatol (mixture of TNT and ammonium nitrate) for a sufficient length of time to have fully investigated all the properties of the mixture and to establish its efficiency

and the methods necessary in its manufacture and use.

At the request of the American Government, Dr. T. Martin Lowry and Major H. L. Armstrong came to this country from the British Ministry of Munitions and assisted in establishing amatol loading. A commission was also sent to England to visit the loading plants there and to obtain information on this subject. Finally on October 26, 1917, amatol was definitely adopted as the American shell filler. It was not all plain sailing, however, in the adaptation of a new industry in this country. Considerable difficulty was encountered not only in securing proper crystals of ammonioum nitrate but also in securing equipment which was suited for this purpose. There were about 15 to 20 variables which entered into this situation.

In view of all these difficulties it was felt that the government should have a small plant in which the work carried on by contractors could be checked and also that could possibly work out new processes or improvements in the processes as adopted. Picatinny was called upon to do this work and a plant was erected in which small quantities of shells were filled. This plant, however, was completely demolished by an explosion which took place in December, 1919.



Pressed TNT and Tetryl Pellets for Loading Boosters and Booster Cavities, also Pressed Black Powder Pellets.

Loading Since July 1, 1919

The close of the war found the Ordnance Department with no arsenal equipped for and capable of loading ammunition. After considerable discussion it was decided that Picatinny Arsenal was the best suited for development into this work. There were certain drawbacks to this selection but taking into account the fact that certain bag loading, smokeless powder, storage, water and power facilities were already available, it was felt that Picatinny was well suited for the undertaking. Money was, therefore, made available for the erection of a complete ammunition arsenal. In August, 1919, the preliminary design work was started. Designs for new buildings were made, old buildings were altered and before long construction work was being carried on at a rapid pace. This work continued until about 1922. In the meantime, however, it had been decided that the metal component phase of ammunition should not be developed at Picatinny Arsenal and this part of the work was abandoned. This means that Picatinny today is not a complete ammunition arsenal, as it has no drawing and forging facilities, and so is incapable of production of some of the metal components of ammunition.

Explosive D

Developments made during the war indicated that the density of loading of explosive D was not sufficiently great to insure that this explosive would stand up on impact with armor plate. Experimental work and tests made indicated that the density must be increased from 1.35, plus or minus .02, to some point above 1.45. Specifications were, therefore, changed so that this density would be uniform throughout the shell, between the figures 1.45 and 1.50. In order to secure this higher density it was necessary to rebuild completely the explosive D plant as the facilities were entirely inadequate in size and quantity. It was also believed that certain of the operations which had been done by hand could be done by the use of automatic or semi-automatic equipment. After considerable study this new plant was finally designed and erected with a capacity of approximately 100—12-inch, 14-inch or 16-inch armor-piercing shells per eight hours.

The movement of the shells in and around the presses is accomplished by means of mechanically driven turntables. A barricade of concrete, heavily reinforced, is so erected that a section of the turntable is within the barricade and passes under the hydraulic press erected therein. The turntables are equipped with four loading stations, one at each quadrant point. A shell, having been placed in a suitable carrier on a truck, is moved on to the first loading station and a charge placed within the shell. The turntable is then moved a quarter turn and another shell moved into position on the second loading station. A charge of explosive is then put into this shell. The turntable is again moved a quarter turn which brings the first shell within the barricade and immediately under the press. These presses are of special design and are of 500 tons capacity when operated at 3500 pounds per square inch water pressure. Another shell is then placed upon the turntable at the third loading station during which time the pressman begins his operations of pressing the charge of explosive in the first shell. The operation from this point is continued, moving the turntable a quarter turn after each pressing, the fourth shell, of course, being placed upon the turntable as the turntable passes the loading station.

The first point to be considered under this subject is one of safety. The shell must be placed centrally under the ram of the press in order to make certain that the ram does not strike the side walls of the shell. Various mechanical

Weighing Propellant Charge for 3-inch Antiaircraft Ammunition.

devices have been installed to accomplish this. There are indicators on the turntable which show the operator when the shell is centered under the press. In addition to this there are hydraulic cylinders with the necessary safety stops attached to them so that these cylinders will move the turntable into a centralized position before it is possible for pressure to be applied on the explosive in the shell. The openings in the barricade through which the turntable passes are provided with armor plate doors which are also operated by hydraulic cylinders. As soon as the valves controlling the hydraulic pressure are opened the water first passes through the cylinders which move the turntable into a centralized position then to the cylinders which close the armor plate doors and then to the ram of the press. In releasing the pressure these operations are reversed so that the ram must be out of the shell before the doors can be opened and also before the turntable can be moved.

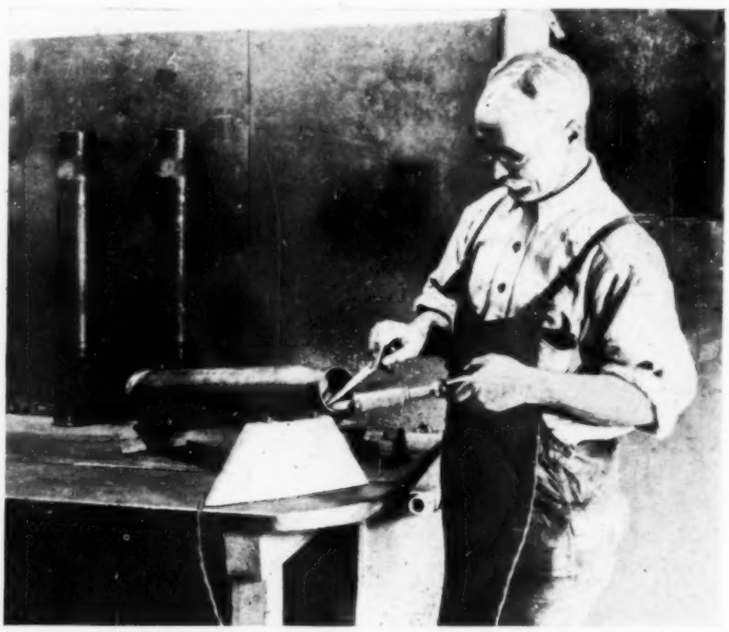
Factors Affecting Loading of Armor-Piercing Projectiles

There are many conditions met in loading shells with explosive D which affect the satisfactoriness of the product:

(a) *Size and Shape of Ram.*—Experiments with all kinds and shapes of rams or plungers show that a flat ram is the best. The diameter of the ram must be carefully determined. A properly designed ram reduces the danger of the operation by allowing all D not pressed by the plunger to have free escape around the sides. This also gives more uniform densities; a larger plunger gives high densities on the sides, a smaller plunger high densities in the center. When the loading is properly carried out, all D is either held firmly under the pressing surface, or is given free escape without undergoing any compression; relative motion of particles within the D which is held firmly is negligible, and the D which escapes is still in proper condition for pressing. If, however, the clearances are too small (clearance area less than 16 per cent of the cross-section of the cavity, or plunger not centrally located in the cavity) the escaping material will be compressed before it gets clear, and will not be in satisfactory condition for re-pressing. It will also be noted that unless small plungers are made long enough, some D may be compressed by the enlarged upper portion of the plunger.

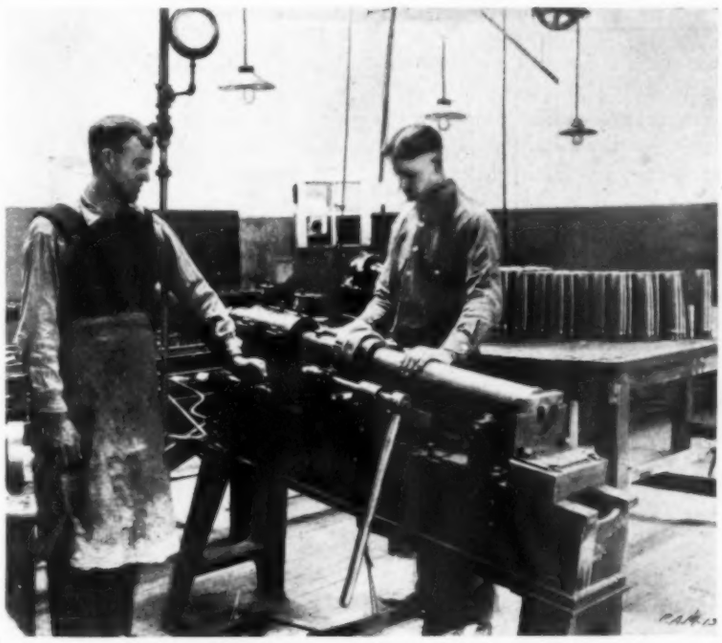
(b) *Human Element.*—In view of the fact that the successful operation of this plant depends absolutely on the pressure applied on the explosive, it can readily be seen that the men operating these presses must be reliable as they must follow the instructions given, to the letter. The rate of application of the pressure and the time of holding the pressure on the explosive must be uniform as disregard of these points alone can give a variation in density greater than the allowed variations in the specifications.

(c) *Size and Shape of Cavity to Be Loaded.*—It has been found that this point is one of the deciding factors in production. A cavity which is deep and sharply pointed is very difficult to load. Numerous experiments have shown that a pressure as high as 30,000 pounds per square inch must be used in order to obtain a density of 1.48 in the point of the cavity in some projectiles. This is due to the fact that rams which are too small in diameter on the point, when used on an extension to reach the point of the cavity, will not stand up under the pressure exerted and further, to the fact that from a safety standpoint the plungers must be kept from striking the side walls of the cavity.



Soldering the Brass Diaphram in 3-inch Antiaircraft Ammunition at Picatinny Arsenal.

(d) *Size and Condition of Crystal or Grain of the Explosive.*—There is so much difference in this condition that a test must be run on each lot of explosive D. Tests indicate that the coarser the material the easier it is to press and that a fine, light, fluffy material is very hard to press. The pressure necessary to obtain 1.48 density will vary considerably from one lot to another. Results show that as the granulation decreases in size the density after pressing also decreases in proportion to the fineness of the granulation. For instance, lots 149 and 402 are regular loading lots of explosive D. Loading tests were made of these lots in 3-inch 15 pdr. cast steel shell. The former lot required a pressure of 7,000 lbs. per sq. inch to load the shell to an average density of 1.51; the latter a pressure of 15,000 lbs. per sq. inch to load to a density of 1.50. The former lot contained a small percentage of material passing through an 80 mesh sieve; the latter contained over 36 per cent. This presents a practical demonstration of the effect upon loading of excessive amounts passing through an 80 mesh screen. 7,000 lbs. per sq. inch upon lot 402 would give a probable density of 1.43 as 8,000 lbs. per sq. inch actually gave a density of 1.45. The difference between 1.51 and 1.43 is .03 greater than the range in density which is permitted in regular loading, i. e., 1.45 to 1.50. Hence, if a variation in granulation were encountered such as exists between the samples mentioned above there would result the rejection of loaded shell unless very wide compensating changes were made in the loading pressures. Lot 149 gave very satisfactory loading results and the granulation may be considered as an approximation to the desired standard. Under operating conditions a maximum output may be expected when using granulation similar to lot 149, but when excessive amounts of fine material are encountered operations must be checked or suspended until results are obtained by experimental loading of shell and sampling for density. The results of finished shell are very erratic when loading with fine granulations.



Assembling and Crimping Cartridge Case to Projectile.

Sewing Powder Charges for the 16-inch Howitzer at the Picatinny Arsenal Loading Plant.

Laboratory results upon the sensitivity of explosive D using tetryl as a booster show the sensitivity curve to be practically a flat, straight line regardless of the pressure to which the explosive D has been subjected.

Experimental work to date indicates the desirability of limiting the granulation of explosive D so that not more than 15 per cent will pass through an 80 mesh screen, but it is not satisfactory at this time to change the specifications since a study must be made of the economic phase of the situation, i. e., it is not certain whether the cost of screening the material to remove the fine granulations or of modifying the process so as to produce only the desired granulation may not be more costly than the increased labor in the loading plant.

This grain or crystal condition is encountered in all pressing work on explosives. Photomicrographs of tetryl, for instance, show great differences. Some lots show crystals which form large irregular conglomerates, while others contain some large aggregate crystals, but for the most part they contain a large percentage of aggregates which have a regular outline. This difference seriously affects the ease of securing density and also the uniformity of loading the explosive when endeavoring to manufacture pellets.

(e) *Size of Increment.*—It has also been found that satisfactory results can be obtained if the length of the pressed increment does not exceed the diameter of the ram. Other than this control on the size of the increment it is

believed that the size is a question of production only. All other conditions can be overcome by a change in the amount of pressure used and the method of the application of the pressure. Weights of increments are determined for each new lot of explosives and each size of shell by experiments, samples being taken at frequent intervals to insure that the shells are being uniformly loaded.

Laced Propellant Charges for the 16-inch Howitzer Showing a Base and Three Equal Increment Charges.

(f) *Supporting of Shells.*—One of the greatest difficulties encountered is the proper supporting of the shell while being pressed. Consider, for instance, the 16-inch shell. The explosive must be pressed in this shell at a density of 1.48. In order to do this a pressure of about 12,000 lbs. per square inch must be applied on the explosive. The ram used is about 8 inches in diameter, or 50.27 square inches, which means a dead load of 603,240 pounds or 300 tons. These shells are all sharply pointed which means a wedging action of the shell in any support provided. Shells have stuck in the supporting blocks so firmly, that it was impossible to remove them. This difficulty was finally overcome after careful study, by the design and manufacture of a support made to very close tolerance, from a special grade of steel.

Propellent Charge Loading

The small plant for propellent charge loading which existed prior to July 1, 1919, has been considerably enlarged and at the present time is capable of turning out 1,000 8-inch howitzer charges or equal, 500 155-mm. gun charges or equal, and 100 12-inch gun charges or equal per eight-hour day. This plant is equipped to manufacture the powder bags and load the black powder igniters for the above charges.

In some of the larger guns, it has been necessary to stack the powder grains end on end in order to get sufficient powder into the chamber of the gun to give the required velocity. This method increases considerably the density of loading. Machinery has been installed to do this stacking work.

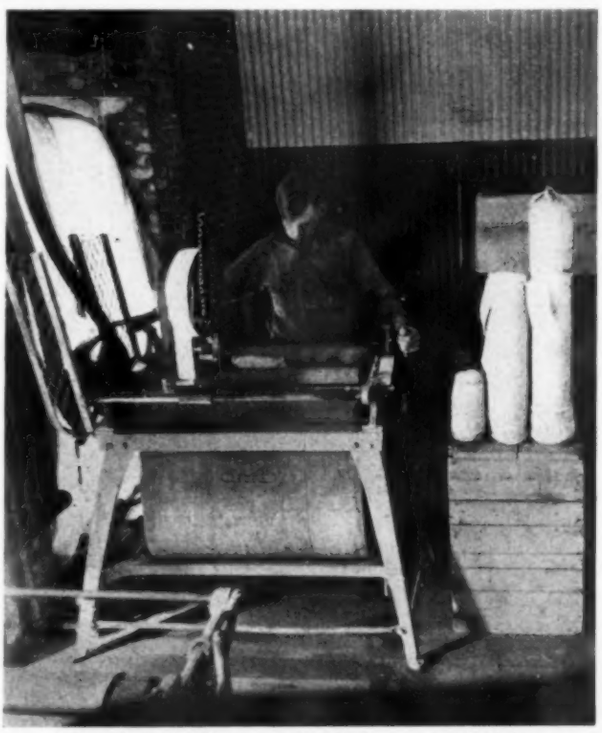
Cartridge cloth, which is made of silk, is difficult to obtain in case of an emergency. Silk not being available in this country in sufficient quantity has to be imported and is, therefore, placed in what is called the strategic class. Efforts are, therefore, being made to develop some substitute. It has been fairly well established that in order to avoid disastrous premature flashes in loading guns, the cartridge bag must be made of an animal fiber. An animal fiber material will not smolder after the main discharge of the gun, and, therefore, no burning particles remain lodged in the bore or chamber of the gun, with the likelihood of setting fire to the next charge inserted. During the last war, wool and mohair were used in considerable quantities as substitutes. The DuPont Company also developed a container known as nitrotite which proved to be fairly satisfactory and 50,000 charges put up in these containers were ordered overseas to test out at the front. They were made of a material which was waterproof and also had the advantage that the container itself tended to replace a certain amount of smokeless powder and was entirely consumed within the gun. It is believed that had the war continued nitrotite would have proven to be a real substitute for silk.

Testing Cartridge Storage Cases for Air-Tightness, Picatinny Arsenal Loading Plant.

Considerable effort has been made to develop a cotton cloth suitable for bag manufacture. It is possible that this may be accomplished, especially for propellent charges where the ratio of powder to cloth is very great.

AMATOL AND TNT LOADING

The 1919 plan for the development of Picatinny Arsenal covered the erection of facilities for the loading and assembling of mobile artillery complete rounds with either amatol or TNT as the shell filler. Sufficient equipment was secured and installed for the loading of 5,000 rounds of 75-mm. (or equal) ammunition per eight hours by either method. Shortly after this plant was erected, however, it was decided that the supply of toluol in the case of another war would be sufficient to take care of our entire needs for shell-loading work. It was then decided that the amatol equipment which had been installed would be removed from the plant. This decision was partly brought about by the fact that some of the shells filled with amatol, which had been loaded during the war, were showing certain defects and it was felt that this substitute explosive should not be used unless absolutely necessary. Since that time it has become quite apparent that experimental work, at least, must be done with substitute explosives and amatol being the best available at this time, it has again been decided to make a small installation for the loading of shells with amatol.



Bag Wrapping Machine for Tightening and Stiffening Propellant Powder Charges—"By the use of this machine, production per operator was increased about 8 times."

As stated above the plant was laid out with a capacity for loading 5,000 75-mm. shells but the fact was also kept in mind that as Picatinny was to be the only ammunition arsenal of this type, it would be called upon to load all kinds of projectiles up to and including 12-inch, and also bombs and trench warfare ammunition. An analysis of past work shows that the majority of orders which have been handled were for large capacity bombs. The only 4,000-pound bombs ever loaded in this country have been loaded in this plant. As a matter of interest, these bombs with fins or stabilizers attached are about 3 feet in diameter and 14 feet in height. It can be seen from this the difficulty which would have been encountered had not this matter been considered in the original designs of the plant.

TNT is used as the major portion of the explosives in loading ammunition. The melting point of TNT is approximately 80° C. Its liquification is easily accomplished in steam jacketed kettles using steam at 5-pound pressure as a heating medium. This permits the loading of TNT by the cast method, thereby obtaining a density higher than can be easily realized from a pressing method. The main difficulty experienced in casting TNT is the formation of pipes and blow holes in the cast, these defects being caused by the contraction of the TNT in solidification. In order to minimize as much as possible the formation of cavities, castings are made in several pours and the crust which forms over the top of the cooling cast is broken down at frequent intervals. By the use of the casting method it is easy to fill any shape of container. The TNT is poured at a temperature just slightly above its setting point so as to reduce the contraction to a minimum and also to obtain smaller crystals in the charge and thus a higher density. In order to prevent cavitation in the shell a "riser," or funnel, is placed upon the top of the shell before the last pour of the TNT is made. More TNT than is required to fill the shell is then poured so that the upper liquid line in the pouring funnel is several inches above the projectile. After solidification of the TNT the funnel containing the majority of the cavitation is broken off from the shell. The fuze cavity is then drilled and the threads cleaned for the insertion of the booster.

It has been customary to pre-heat projectiles before loading with TNT but recent experiments have shown that the cooler the projectiles the higher the density of the cast TNT and it is possible, therefore, that this pre-heating may ultimately be discontinued. If so done it will be necessary, however, to have the shell storage buildings and the pouring rooms at a uniform temperature in order to avoid condensation within the shell.

One of the greatest hazards in loading of ammunition is in the drilling of the booster cavity. It may be possible to do away with this drilling by the use of a former through which the last charge can be poured. Experiments are being made on this basis and indications are that it will work out satisfactorily. Considerable experimental work has been done in the loading of TNT, and it is believed that the present practice can be changed to advantage in several cases. For instance, it is believed that a good portion of the loading and assembling of small caliber ammunition can be done by the use of automatic or semi-automatic machinery. Progress has been made in the development of loading bombs and larger shells by the use of the "pellet" method. In this method a certain amount of liquid TNT is placed within the shell and cast pellets of TNT are then dropped into this liquid and tamped until the liquid has taken up all the pellets possible and has solidified. The 2,000-pound bomb which by the casting method takes 48 hours to load can be loaded in about 3 hours by the pellet method. It is believed that these pellets can be manufactured at the TNT manufacturing plant and shipped to the loading

plants ready for dropping into the bomb. This method has in its favor not only the speed of production but also the fact that a considerably lesser capital investment will be needed for the erection of loading plants due to the fact that large floor spaces will not be necessary for cooling rooms. At the present time it is not believed that any real economy in loading will be affected by pellet loading, due to an increased labor cost, but it is believed that the speed element alone warrants considerable effort in developing this method. The only obstacle in the way of this development at present seems to be in the securing of pellets of a uniform size. TNT can be readily cast into layers approximately ½-inch thick without cavitation but so far no method has been developed whereby TNT so cast can be readily broken up into pellets of uniform size.

The carton method of loading also presents some possibilities. This method was used during the past war by the Germans. Cartons of paper or light metal made of the proper shape to fit into the various shells or bombs are loaded with explosives at the loading plants, shipped to a central assembling plant and there placed in the proper shells or bombs. This method has in its favor a great saving in the cost and difficulty of transportation of heavy metal shells and bombs to the loading plants.

FUZE, BOOSTER AND PRIMER PLANT

In view of the fact that the entire loading plant at this arsenal was designed, keeping in mind a production of 5,000 75-mm. complete rounds per 8-hour day, it was necessary to install production facilities for the loading of an equal number of the main components. The most important change which has been made in standard practice of loading these components is that of making practically all of the explosive components into pellet form, inserting these pellets into the cavities and then consolidating them rather than pressing loose explosives.

Fuzes present the most difficult problem in the loading plant, especially the assembly operations. Extreme care is necessary to assemble the surprisingly large number of parts (in some fuzes as many as 50) in a manner such that the fuze will work successfully. It is remarkable how often apparently unimportant things will cause fuzes to fail. There are also many assembly operations that are very hazardous and the operators must, therefore, be carefully trained. Parts may also be inserted in the assembly incorrectly which will cause the fuze to be unsafe.

Careful preliminary layout of plant, training of employees and continuous inspection are necessary. Since the fuze is the "brains" of a complete round no expense should be spared in producing a perfect mechanism. As a general rule the cost of a fuze is a comparatively small percentage of the total cost of a complete round of ammunition. It is not economy then to sacrifice anything in quality for quantity production, as the failure of a fuze to function means not only the loss in money of the expensive complete round but also the firing with absolutely no effect on the enemy after great effort has been expended in production and transportation, and also the exposing to no avail of our troops to enemy fire.

CONCLUSION

The loading problem is difficult for one not only has to deal with his own shortcomings, but also the errors and oversights of others. The loading plant must get ammunition to pass ballistic tests, yet a great many rejections are directly traceable to poorly designed or manufactured metal parts, mechanical failures, or imperfect components which have been overlooked by inspectors in the rush of a great production.

Efforts are being made to prepare complete production records on all work handled at Picatinny Arsenal. These records include all plant equipment and methods, cost records, difficulties encountered and their corrective measures. Efforts are also being made to standardize wherever possible. It is believed that these records will prove of great value in case of an emergency, as they will be available for contractors as standard practice to be followed in the loading and assembling of ammunition.

Col. Frank A. Scott, Ord. Res., Chief, Cleveland Ordnance District, Honored

COL. FRANK A. SCOTT, Ord. Res., a Director of the Army Ordnance Association and Chief of the Cleveland Ordnance District, was honored by Western Reserve University June 16, 1926, when he was the recipient of the honorary degree of Doctor of Laws.

Colonel Scott is one of the foremost industrial preparedness advocates of America, having served as first chairman of the War Industries Board, 1917. He was presented for the degree by Hon. Newton D. Baker, former Secretary of War.

In conferring the degree, Dr. Robert E. Vinson, President of the University, said, "Frank Augustus Scott, for life-long pursuit of culture, for the application of the powers of a constructive mind to problems municipal, state, and national, and for the benefits secured through your unselfish public service, upon recommendation of the Faculty and by the authority of the Board of Trustees, I confer upon you the degree of Doctor of Laws and present you to oncoming generations of students as an example worthy of emulation."

High Explosives

C. J. Bain

IMPROVEMENT in ammunition is brought about in the same manner as improvement in articles of trade, namely, through correcting the defects which make themselves apparent after extended service. While this practice can be applied readily to what may be called commercial articles, it is not entirely feasible in the case of ammunition. It is true that tests carried out on a few hundred rounds will give fairly accurate data as to the merits of a given component, yet the final decision cannot be made until thousands of rounds have been subjected to test. Thus from the results of taking stock of the ammunition situation after the World War, it was seen that improvement of various components of the complete round was of prime importance. Again, the continued storage of millions of rounds of ammunition for a period of nine years has brought to light additional defects which should be eliminated in future production.

Investigations into the malfunctioning of ammunition in service, and deterioration during storage, have shown that the high explosives used in this ammunition should be credited with a portion of the imperfections and, therefore, their improvement becomes imperative. Upon high explosives is placed the responsibility for destruction of the objective when the missile hits its mark. If this does not take place, expenditure of the entire round has been of no avail. There is still another requirement which is more critical with shell fillers than with other components, namely, the ability to withstand long periods of storage without deterioration. The advisability of this statement can best be realized by visualizing the replacements of deteriorated or defective components. New fuzes and propelling charges can be supplied without any other cost than that of the new components, but the removal of the bursting charge from shell or bomb involves a hazard which is to be avoided where possible. Thus, improvement in ammunition necessitates the proper selection and use of high explosives, quality of which is such that they will function even after years of storage. The production of high explosives of quality requires that the process of manufacture be developed to a point where this desired quality is assured, in which work Picatinny Arsenal is actively engaged.

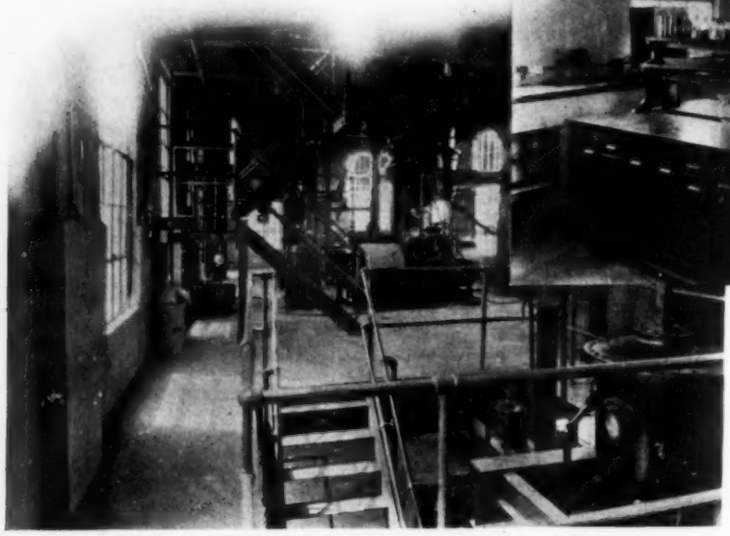
At this point, it might be well to briefly outline some of the deficiencies encountered in the high explosives used during the World War and thus obtain a better understanding of the present need for development work. The principal high explosives used during the war were TNT, 80–20 amatol and 50–50 amatol for field artillery shell and bombs, explosive D for armor-piercing shell, nitrostarch explosives for trench mortars and grenades, TNT and tetryl for boosters, and mercury fulminate for detonators. All of these were manufactured under the stress of production where quantity rather than quality was the determining factor. In other words, their quality was no higher than that required to assure a relatively high percentage of functioning after a limited period of storage. Being manufactured for immediate consumption, little, if any, consideration of their storage life was warranted. However, large quantities of this ammunition have been placed in storage for use as War Reserve and for training purposes, thus providing an excellent opportunity to study the behavior of ammunition in storage and its performance after protracted storage. In a comparatively short time prematures occurred when firing shell loaded with 80–20 amatol. This was followed by deterioration in the form of exudation of oily products in shell loaded with 50–50 amatol and with TNT. Both of these have been extensively investigated to determine the cause and thereby provide against future troubles of that nature. Malfunctioning was also noted with boosters loaded with TNT and tetryl. The use of TNT as a booster explosive during the war was occasioned by the lack of an adequate supply of tetryl, this deficiency being largely due to unfamiliarity with the process of its manufacture. As the explosive characteristics of tetryl are superior to TNT, its use as a booster explosive was highly desirable, hence a clear understanding of the process of manufacture was essential. The remaining service explosives, explosive D and mercury fulminate are the only two high explosives which have given little, if any, evidences of deterioration or malfunctioning.

As ammunition allocated to the War Reserve is depleted through deterioration or expenditure, it becomes necessary to provide replacements. It would be decidedly bad practice to replace with the same grade of material which has proven itself to be defective. Now the only way by which the quality of an explosive can be raised, is to become so familiar with its manufacturing process that all factors which contribute to its quality are known and understood. It is this objective which controls the high explosive development at Picatinny Arsenal.

There is still another consideration to be given to the high explosive situation. The supply of raw materials for the standard explosives may be adequate during peace time while under war conditions their procurement might be entirely cut off or seriously curtailed. Therefore, it is essential that ample provision be made for the manufacture and use of substitute high explosives. This situation is also realized in the development of high explosives at Picatinny Arsenal.

Sound plans of development can be drawn up, but without proper facilities for putting these plans into operation, very little will be accomplished. Thus, appropriate buildings and equipment must be provided or developed. Accordingly in the years of 1920-21 there were erected nine permanent buildings to be devoted entirely to the development of processes for the manufacture of high explosives. With the present equipment it is possible to study the

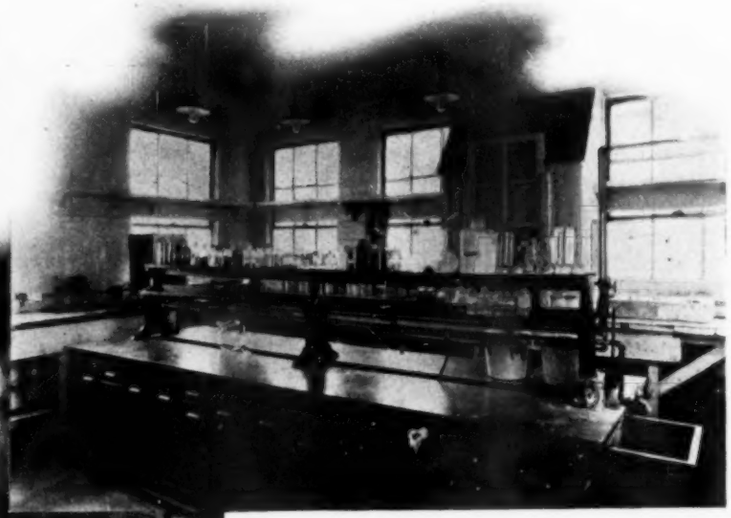
manufacture on a semi-works scale of a large variety of explosives. At the present time one building is assigned to each of the following processes:—the manufacture of raw materials such as dicyandiamid, guanidine nitrate, pentaerythrite, etc.; manufacture and purification of tetryl; manufacture and purification of TNT; purification and reworking of explosive D; drying of high explosives; grinding and sieving of high explosives; and purification of potasium chlorate. Besides these, there are provided ample storage tanks for raw materials, such as nitrating acids. An adequate control laboratory has also been furnished.



Interior, Raw Materials Building, Picatinny Arsenal.

TNT Purification Apparatus, Picatinny Arsenal.

In choosing the installation for the various processes, it has been the aim to select wherever possible equipment which was considered standard and thus avoid the accumulation of special apparatus. That flexibility of equipment has been obtained, can best be judged by a brief summary of the following processes which have been developed during the past few years.



High Explosives Control Laboratory, Picatinny Arsenal.

1. *Purification of Potassium Chlorate.*

As a result of the investigation into the cause of failure of primers during the war, it was concluded that the potassium chlorate should contain no bromate. A method of purification that insures the absence of bromates has been tested on a plant scale and several thousand pounds manufactured which met the revised specification in every respect.

2. *Reworking Scrap Explosive D (Ammonium Picrate).*

In loading armor-piercing shell with explosive D a considerable amount of scrap is produced which is more or less contaminated with foreign material. Also a fairly large number of the lots of explosive D manufactured during the war were found to contain an amount of free ammonia in excess of that allowed by specifications. In order to save both classes of material from the burning grounds, a method has been developed for the recovery of this material whereby approximately 500,000 pounds of explosive D have been converted into material meeting the present rigid specification.

3. *Manufacture of dicyandiamid, guanidine nitrate and nitroguanidine.*

These materials have shown sufficient promise as ingredients of high explosive charges or of propellent powders to warrant a study of their manufacture. The processes have been brought up to a point where it can be definitely stated that they can be applied to large scale production with every assurance of practicability.

4. *Pentaerythrite Tetranitrate (PETN)*

Primers containing suitable proportions of PETN have

demonstrated their ability to bring about ignition of improved propellent powders which were not readily ignited by the service primer. The method for its production was

Acid Storage Building, High Explosive Area, Picatinny Arsenal.

developed in the chemical laboratory and afterwards transferred to the semi-works plant. This material has been made in lots of 80 to 100 pounds and production can be said to have been fairly well established. It is believed that this represents a much larger production than has been attempted at any other place in the world.

5. *Manufacture and Purification of Tetryl.*

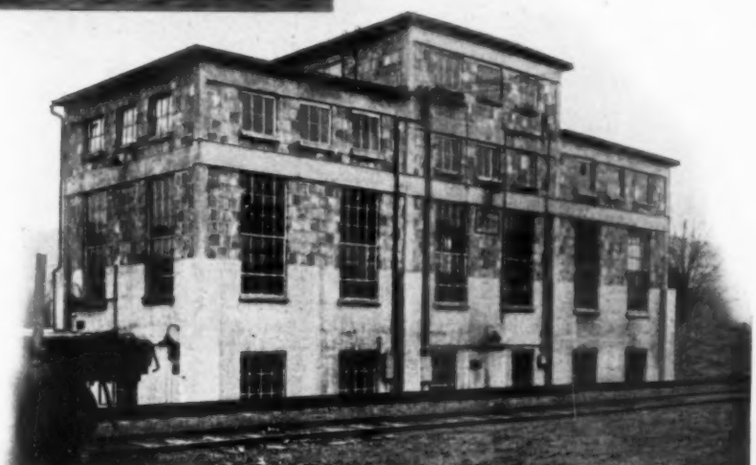
The explosive characteristics of tetryl allowed it to be classified as the ideal booster explosive. Its manufacture during the war was considerably curtailed on account of meager manufacturing data which resulted in a product of none too good quality. The manufacturing procedure has been studied from all angles until at the present time the semi-works plant is producing tetryl which can be labeled as practically chemically pure.*

The foregoing are the major items on which development on a semi-works scale has been concentrated. However, numerous other high explosives have been studied and their method of manufacture developed to a point where large scale production is possible, namely, trinitronaphthalene, tetranitronaphthalene, cyclonite, nitrated castor oil, nitrated linseed oil, mononitroxylene, dinitroxylene, and guanidine pierate.

We now come to a consideration of the future. It is quite true that considerable has been accomplished in the improvement of high explosives, but the major portion of the development lies in the future as indicated in the following discussion of high explosive problems.

1. *Initiating Explosives.*

Mercury fulminate has long led the field as an explosive for use in detonators, and there are very few cases of proven malfunctioning on record. Yet it is well known that there are at least two factors which must be guarded against if deterioration is to be avoided, namely, heat and moisture. The first may be encountered at any time during



Raw Materials Building, High Explosive Area, Picatinny Arsenal.

Explosive D Purification Building, Picatinny Arsenal.

*Tetryl: Development of a manufacturing process at Picatinny Arsenal.—C. J. Bain, Army Ordnance, Vol. VI, No. 36, page 435.

storage, especially in hot climates, while special loading precautions are required to overcome the latter. For these reasons, plans for the improvement of high explosives must include programs for the development of an initiating explosive which is not so susceptible to the influence of heat and moisture as mercury fulminate.

2. *Booster Explosives.*

Even though the quality of the tetryl produced under present practice is all that can be desired, there are further refinements in the process worthy of consideration before the word "completed" can be written. In a model explosive plant, no portion of the spent acids are lost, but are separated by some means from the explosive and recovered by denitration or by returning them to the system. It is to this end that the future work on tetryl will be carried out. Having arrived at the desired quality, attention will now be focused on reducing the cost of the product by means of recovery of the spent acids. Sufficiently favorable results have been obtained in the laboratory to warrant a trial of spent acid recovery on a semi-works scale. Should this prove successful the next step will be the denitration of the spent acid and the utilization of the products of denitration in the production of additional tetryl.

Even though the major portion of the booster explosive development has been confined to tetryl, the other side of the question has not been lost sight of, namely, the discovery of a substitute for tetryl. A study of high explosives indicates that there are three other explosives which are deserving of a thorough trial; cyclonite, picric acid and tetranitroaniline. Sufficient of these materials are on hand to carry out the necessary tests, and until such tests have been completed, any investigation into the method of manufacture would not seem justified, for booster explosives as well as all other high explosives, must justify by their performance any development of their methods of manufacture.

3. *Bursting Charges.*

For many years TNT has been considered the most satisfactory bursting charge. It has all the characteristics desired in a filler for high explosive shell or bomb, and for some time no serious consideration was given to its improvement. Then reports of exudation started to come in until at the present time this defect of TNT has assumed considerable importance. The seriousness of the situation is fully appreciated and studies are being made with a view to overcoming this disadvantage. As soon as laboratory work has been completed, it is planned to start semi-works development on methods of manufacture and purification in an endeavor to produce a TNT which can be counted upon to withstand storage without exuding. If this experimental work is successful, the problem of a high explosive charge for field shell and bombs will be solved for peace-time loading only.

In the event of war, it cannot be expected that there will be a sufficient supply of toluene to meet the needs of all branches of the service. Thus substitutes for TNT must be developed and thoroughly tried out during peace time so that there may be no hesitancy in their use during an emergency. Therefore, the development plans include investigations into the possibilities of various explosives. The ones of immediate concern are amatol, TNX, picric acid and dinitrophenol. The first two named as used during the late war will still necessitate a demand upon TNT, and will, therefore, be only a step in the right direction. Investigation of a high explosive which will totally replace TNT, and which can be easily loaded, is warranted, and for this reason picric acid-dinitrophenol is being considered.

Various other explosives are also worthy of trial, but it is only through concentrated effort on a few at a time that progress can be expected. If any or all of the high explosives mentioned fail to meet the requirements, then and only then will investigation of other explosives be justified.

As development of ammunition proceeds, the demand for new equipment goes hand in hand. It is the aim to purchase and install such new equipment as the status of development indicates, thus preventing as much as possible any scrapping material. By a close adherence to a policy of this nature the equipment of the semi-works plant will proceed slowly but effectively until within a few years there should be located at Picatinny Arsenal, the largest and best equipped semi-works development plant of its kind in existence. Modern equipment, ideal surroundings and hearty cooperation are three important factors in determining the quality of work produced. Thus the future development of high explosives at Picatinny Arsenal can be viewed with a good deal of confidence.

The Relation of Picatinny Arsenal to Field Service

Fred Olsen

THE resemblance between cantaloupes and ammunition is not so remote as might appear on the surface. The cantaloupe is used only once, and so is a round of ammunition. You can tell just as much about the chances of a satisfactory result by looking at the round as you can by looking at the rind. The problems of transportation, storage, and distribution are quite similar for both commodities, the main thing being to furnish the article to the consumer in a satisfactory condition at the right time and place. The analogy can not, however, be pursued too minutely, since for example the responsibility for their design rests with two entirely different establishments, Picatinny Arsenal being charged with the design of the ammunition. However, just as the fruit dealer can contribute to the improvement of cantaloupes by accepting and distributing only the very best grade of fruit, so can the Ordnance Field Service affect the design of ammunition by its constructive criticism of the quality of the ammunition entrusted to its care.

It is hoped to show in this article wherein Field Service can and does contribute to the improvement in design by furnishing data regarding the good or bad behavior of ammunition during transportation, storage, and expenditure. The ammunition designer is very much dependent upon Field Service for information regarding those features which must be incorporated into the design of a round of ammunition to ensure that it will function after protracted storage, and that it will be convenient and safe to handle, store, and issue. The combined efforts of the mechanical engineer and the explosive engineer may be relied upon to produce a round or a component which will function satisfactorily when tested immediately after manufacture, but it is only from Field Service that information can be obtained as to how this ammunition behaves in storage or how it functions after long periods of storage, and without these data, improvement in ammunition will be seriously hampered.

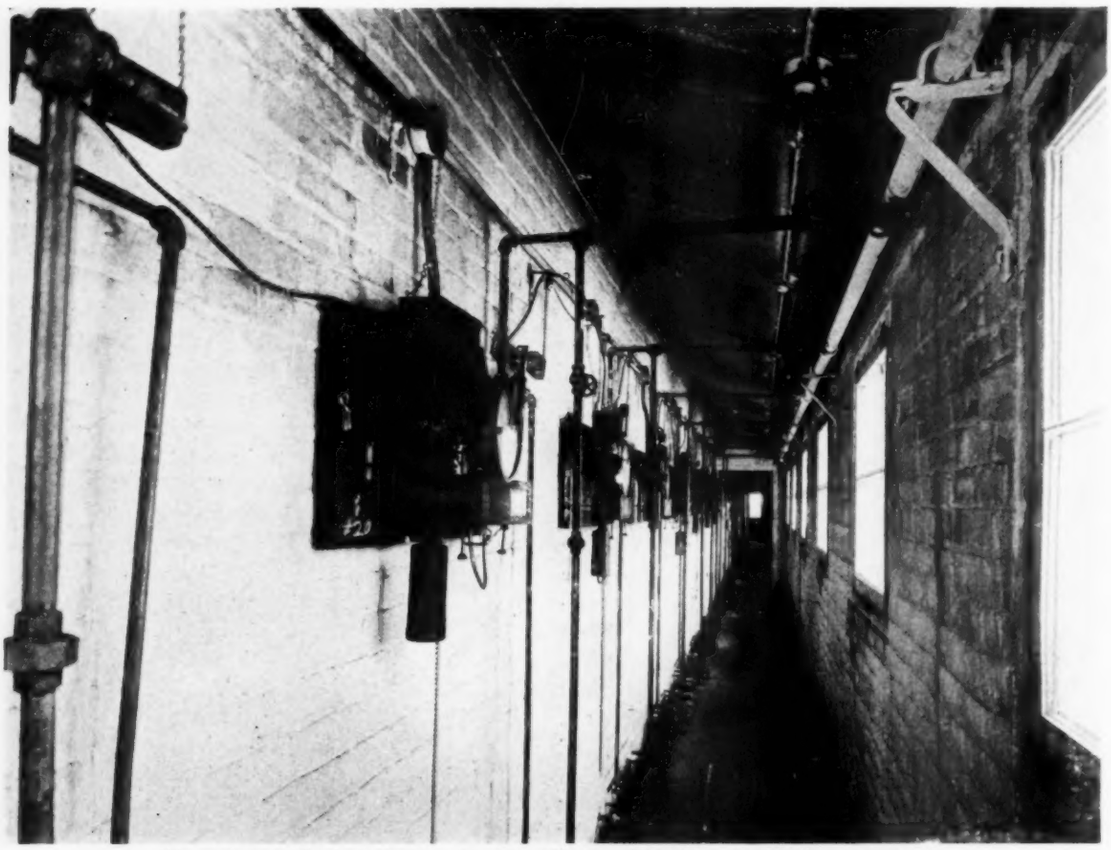
The direct responsibility of Picatinny Arsenal, acting under the authority of the Manufacturing Service of the Ordnance Department, lies mainly with the development and manufacture of ammunition. When a round has been manufactured and accepted it is turned over to the custody of Field Service, which is then responsible for its storage and distribution or disposal. Nevertheless, Picatinny Arsenal endeavors to maintain contact with the ammunition throughout its life, in order to serve in a consulting capacity to the Field Service by furnishing technical information regarding the ammunition, especially when any anomalous condition is encountered, and, at the same time, to study its behavior in service. This contact is effected through the military personnel of Field Service, the Ammunition Foremen and the Surveillance Inspectors.

The Ammunition Foremen have received their technical training at Picatinny Arsenal and are continuously in touch with conditions in the field, and they are, therefore, in a favorable position to impart to the Arsenal that information regarding the behavior of ammunition in service, which will assist in the correction of design, or in the reconditioning of defective components.

Through the medium of the Surveillance Inspector the conditions of ammunition and especially the stability of powder in actual storage are being ascertained.

Since Picatinny Arsenal is responsible for the development and manufacture of ammunition its contribution to Field Service is therefore the very essential one of providing a round which will function satisfactorily after storage. This is by no means the same as providing a round for immediate use; in fact, there is a growing recognition of the necessity for two kinds of ammunition, one for use in an emergency, the other for war reserve. In the design of the latter there is involved the consideration of many features which do not contribute directly to the functioning of the round, but are rather for the purpose of combating the ravages of time and weather. Such features are metal plating to avoid corrosion and rusting, waterproofing, high purity and stability of the explosive elements, appropriate marking to aid in identification, all of which contribute to lighten the burden of the Field Service by providing ammunition which requires less close surveillance and less renovation, and can be handled with less confusion. In this last connection the present policy of providing fixed ammunition in the form of completely assembled rounds, where possible, is of distinct benefit. Previously the medium caliber base-fuzed projectile was shipped as an item distinct from the cartridge case, the fuze, and the base cover and caulking wire, and the assembly had to be made at the battery. Also the fins, boosters, fuzes, and primer detonators were formerly packed separately from the bombs in which they were to be used. The practice of shipping completely assembled rounds has benefited Field Service by decreasing the amount of bookkeeping, and by avoiding confusion at the time of transportation and issue.

Numerous features have also been incorporated into the design to insure safety and convenience in handling and shipping. The construction of the components must be sturdy, and appropriate packing boxes must be provided. For example, the packing boxes must be clearly marked to show the nature of the contents, and must be capable when loaded of being conveniently handled by not more than



Temperature Control System for Surveillance Chambers at Picatinny Arsenal.

Apparatus for High Temperature Stability Tests on Propellant Powders and High Explosives at Picatinny Arsenal.

two men. Usually the design is such as to permit stacking in magazines or insertion into the compartments of regulation ammunition wagons. Special tests have been developed to determine the ability of the round and its components to withstand rough handling, such as the jolt and jumble test for components and the tumbling barrel test for packing boxes. The jolt and jumble test has been described by Mr. H. M. Brayton in his article on Fuzes in the current issue of this journal. The tumbling barrel test consists in subjecting the box containing inert loaded rounds to a tumbling action in a specially designed large barrel provided with various baffles and obstacles, which gives the box a very severe buffeting.

Equipment for Static Fragmentation Tests of Ammunition at Picatinny Arsenal.

In connection with the storage of ammunition an elaborate system of surveillance testing has been devised, which comprises field tests on the material in storage at the depots or posts and control tests on master samples of certain components at Picatinny Arsenal.

Most of the high explosives employed for military purposes are inherently of good chemical stability. It is extremely improbable that even the poorest sample of the lowest grade of TNT will show any signs of chemical decomposition whereby it loses part of its nitrogen, carbon, etc., during the next hundred years. However, a condition of serious deterioration of certain TNT and amatol charges has been observed, this change being attributable to a physical segregation of impurities, which were present originally in the charge, and which have migrated during several years of warm storage to the booster cavity or to other parts of the charge as an oil. In many instances this migration has been sufficient to cause exudation of the oil from the shell. Picatinny Arsenal studied the nature and cause of this exudation and has shown that there is no peculiarly hazardous condition attending the handling and storage of shell showing exudation, but that the shell is unfit for issue. Work is now under way to show what is the best method of renovation of the shell, and also to determine how this exudation may be avoided in future ammunition.

On account of the instability of nitrocellulose powders, much closer surveillance is required. Although their average life is fifteen years, some service lots have decomposed so much in six years that they have had to be destroyed. In some cases powders have been found to deteriorate so rapidly after a certain critical point in their life has been reached that especial care must be taken not to miss the first indications of instability. The most thorough system of testing, therefore, is employed in the continuous surveillance of propellants.

When a lot of smokeless powder is manufactured, a representative sample is selected which is held at Picatinny Arsenal as a master sample of the lot. Portions of this sample are subjected semi-annually to two tests: (1) The 135°C Methyl Violet Test; and (2) The 65.5°C Surveillance Test.

Field Service subjects the powders in storage to the same tests and, in addition, employs an observation test upon samples in the magazines.

The master samples are kept under practically ideal storage conditions, so that the surveillance tests really enable Picatinny Arsenal to determine the inherent stability of the powder, whereas the Field Service tests are influenced by those changes which have taken place in the powder due to actual field conditions of storage. If the stability of the master sample at Picatinny Arsenal is bad, it is certain that the same lot in storage at some depot can not be stable, and recommendation is made to Field Service that closer surveillance is necessary, if the lot is of not too greatly impaired stability, or that immediate destruction of the lot should be carried out, if such is warranted.

If, however, field tests show that the samples tested are unstable, while the master samples at Picatinny Arsenal continue to show satisfactory stability, attention is then focused upon the conditions of storage which have influenced adversely the stability of the powder.

Contrary to a prevalent opinion, powder of quite low chemical stability is usually not ballistically unsafe. As a matter of fact, powder which fails to pass the surveillance test has probably decomposed to a point where part of its nitrogen has disappeared and the explosive characteristics have been diminished. Thus, such a powder will give low rather than high pressures, with correspondingly lower muzzle velocities. Powder which may be dangerous to shoot is unfortunately not detectable by stability tests, but can only be recognized by a difficult chemical test to determine its total volatile content or by microscopic examination. If the powder has been stored in leaky containers in a dry atmosphere, the escape of volatile material may have so increased the rate of burning of the powder, its temperature of combustion, or in other words its potential, that excessive pressure may be encountered. Any marked

degree of brittleness, which may have been developed in the powder due to an extreme loss of solvent, will tend to accentuate the rate of burning, and therefore, the development of excess pressures. At the present time not very much can be done to forewarn the using service of a growing tendency on the part of a particular powder to yield high pressures. It is only when such pressures are encountered in actual firing that Picatinny Arsenal can be called upon to investigate the cause of the abnormal behavior. When powder of good stability is found to have a low volatile content the recommendation is usually made to "reproof" the powder, or to withdraw it from service.

Prevention of loss of volatiles is, therefore, of extreme importance, and after the acceptance of a lot of satisfactory stability the operation of all subsequent preventative measures lies with the Field Service. The most important of these is the maintenance of an air tight condition of the powder containers. With the present type of nitrocellulose service powder exposure to warm humid atmosphere is more provocative of deterioration than any other factor, and the importance of air tightness of powder containers can not be over-emphasized. It is believed that tests carried out to determine whether or not containers are leaky are of much greater significance than those which determine the stability of the powder within those containers. It is not a little disconcerting to realize that tests have indicated that a probable minimum of 30 per cent and even up to 50 per cent of the bulk powder boxes are leaky. The seams in the zinc liners of the boxes open up during transportation and the gaskets shrink and crack as the rubber ages. Nor is there an easy or immediate remedy since the construction of the boxes does not lend itself to testing in the storage depots. Deterioration of smokeless powder stored in leaky containers is being studied as part of a very elaborate program, involving the storage of several thousand pounds of carefully prepared samples at Charleston Ordnance Reserve Depot, Curtis Bay Ordnance Reserve Depot and Picatinny Arsenal.

This test originated in the observations of surveillance inspectors at certain Ordnance Reserve Depots. These observations had revealed the fact that some lots of cannon powder did not have uniform stability, and that varying degrees of stability could be associated with variations in the color of the grains. It was found that yellow or orange spots occurred in certain grains and that these spots were friable, of low nitrogen content, and of high acidity, and when single grains were ignited in the open they burned slowly, leaving a considerable residue. The stability of these grains as judged by the 135°C heat test was very bad, some samples exploding in the test in ten minutes, whereas other grains from the same box of powder, which showed no such discoloration, required the usual 60 minutes or more for the discoloration of the test paper and gave no explosion in five hours. This discoloration has not been observed in any lots in storage at Picatinny Arsenal, but has occurred in southern depots, only however in powder of war-time manufacture. The cause of the discoloration has not yet been traceable to any definite condition, such as the use of low grade cotton linters, impurities in the solvents employed, the use of the water drying process, etc.

A point of vital interest is the danger involved in the storage of powder containing these deteriorated grains. Although none of the fires, which have occurred recently at Reserve Depots, has been traceable to lots of powder containing such grains, it is to be expected that danger of spontaneous ignition exists in all lots, which contain an appreciable amount of the bad grains, since tests have shown these to be extremely unstable. It is, however, quite significant that the very extensive fire at Old Hickory in 1924 had its origin in powder of small web stored in containers which were known to be in a very leaky condition. It is also of importance to know whether these evidences of deterioration are increasing because of the development of discolored regions from inherent centers of instability, or whether good grains are "infected" by the acid spots of bad grains in their vicinity. Accordingly the "bad" grains in a lot of powder at Charleston Ordnance Reserve Depot were carefully separated by hand picking and these bad grains were added in definite weights to "good" powder to give proportions of "bad" grains varying from 0.1 per cent to 20 per cent. Part of these prepared samples were placed in air-tight powder boxes and part in similar boxes from which the rubber gasket had been removed, and in which definite exposure to the atmosphere is secured. These boxes were placed in widely separated, especially constructed, miniature wooden magazines, one box to a magazine, so that in the event of spontaneous ignition it can be definitely ascertained which sample is responsible for the fire. These samples are in storage at Charleston, Curtis Bay, and Picatinny Arsenal, and will be held until spontaneous destruction of the samples occurs. Periodical tests are being made to determine any increase in the percentage of deteriorated grains which may occur in protracted storage. In the course of this study an effort will be made to develop improved stability or surveillance tests which will enable still closer predictions being made regarding the life of the powder.

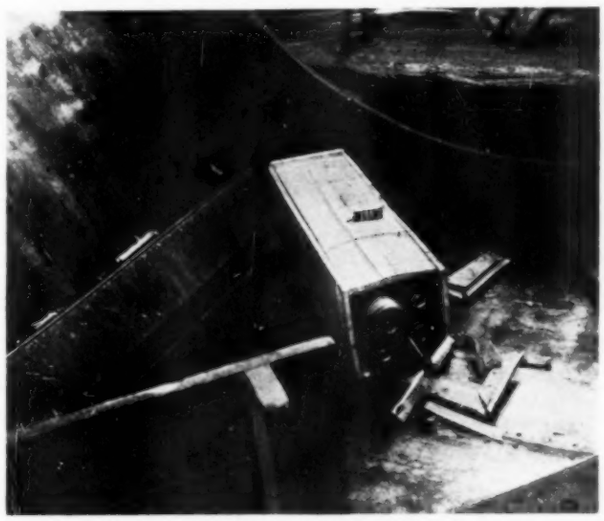
The question has often been raised that if such great care must be exercised in keeping service powder out of contact with moisture, wherein can lie the advantage of the much discussed scheme of the Under-Water Storage of Smokeless Powder. The advantages are probably twofold. The temperature is considerably lower on the average, and does not reach temporary high values. Also, what is possibly of greater importance, the heat, which is liberated during the decompostion of nitrocellulose, and which may cause local conditions of relatively high temperatures in ordinary storage, because of the poor conductivity of the powder grain and the relatively well insulated conditions in the powder box, is rapidly removed by the water in direct contact with the grain. If firing tests continue to show that powder now being stored under water at Picatinny Arsenal gives satisfactory ballistic results, several problems of Field Service will be considerably lessened. Hazards of storage will be practically eliminated, the policing of the area will be greatly simplified, and the material may be available for a much longer period.

Another solution of the powder storage problem, upon which work is being strenuously pushed, is to provide the service with only non-hygroscopic powders, i. e., powders which are reasonably immune to the action of a moist

atmosphere. In this connection the results of tests now being obtained on a current program concerning the stability of the newly developed non-hygroscopic powders are of great significance. It has been shown that the stability of propellants is proportional, other things being equal, to the decrease in their hygroscopicity. Powders which have been prepared in such a way as to reduce their hygroscopicity have considerably outlived the present service powders, when stored in a saturated atmosphere at 65°C.

Before leaving the problems of surveillance it should be pointed out that the care of other components is analogous in many ways to that of the powder. For example, semi-annual inspection and tests are made upon the vast quantities of silk cartridge cloth in storage.

In connection with the expenditure of ammunition Picatinny Arsenal is almost entirely on the receiving end with respect to technical information. It is from the military and civilian personnel of Field Service that the behavior of ammunition in field tests or use is ascertained. As defects in ammunition appear these are studied, and, where it can be accomplished, these are corrected in the existing ammunition, and where not, the endeavor is made to eliminate such defects in future designs. Particular emphasis is, of course, paid to all cases where hazardous conditions are encountered, such as in prematures, since it is usually by such investigations that major modifications in design, nature of explosive components, or methods of loading, are made. Also where field use has shown certain ammunition to give consistent malfunctioning, or where unusual characteristics have been observed in storage, representative rounds or components are usually forwarded to Picatinny Arsenal, with a complete report of the attending circumstances. Facilities exist there for the disassembling, sectioning, and detailed examination of the ammunition. The mechanical condition of the parts and the quality of the explosive elements are carefully determined, and usually static fragmentation tests are carried out to ascertain if the various parts of the explosive train are functioning satisfactorily.



A Box of Ammunition Broken in the Box Test. (Courtesy of Container Testing Laboratories, Inc., Rockway, N. J.)

This work is quite similar to that of the general practitioner who is studying continually the defects of the complete round of humanity in his community. The same ailments keep on coming to his attention so that in many cases it is relatively simple to prescribe remedial measures, and also in many cases to establish preventative methods for the avoidance of the malady.

The ammunition diagnosticians and surgeons examine or operate on defective ammunition, observing, for example, that where prematures occur with a certain type of ammunition there is usually associated a faulty condition in the shell charge traceable to improper loading methods, or that when duds are encountered these are very frequently found in shell which have shown signs of exudation of TNT oil, or in which the booster charge was inadequate or insensitive. When the same kind of malfunctioning occurs quite frequently, it is very often possible to conclude from the nature of the malfunctioning and the known history of the lot of ammunition just where the examination should begin to find out what the causes were, without subjecting the entire round to a detailed examination. Without investigations of defective ammunition, however, it is not to be expected that data would be forthcoming which would show the need for modifying the design of the components. How can the explosives chemist know how pure the TNT should be? His laboratory or field tests can indicate just how difficult it is to effect the detonation of the various grades of TNT. But such tests do not contemplate the changed conditions, which are imposed by the segregation of the impurities in the same grades of TNT, when cast charges are allowed to remain in warm storage for several years. The fuze and booster system which was designed for a given projectile, and tested in that projectile freshly loaded with the prescribed bursting charge, may not have a great enough factor of efficiency to effect the detonation of the same bursting charge after this has remained in storage for many years.

In conclusion, it is desired to emphasize that it is only during the development stage in the life of ammunition that the engineer can incorporate the sum total of his experience into the design of the round. In this stage it is still an idea embodied or illustrated in metals and organic chemicals, and susceptible of modification as the mind of the designer desires. With manufacture, that which was mobile has become fixed, the round of ammunition is now inflexible, and Field Service becomes the guardian of its merits and its demerits. If the Field Service Officer, Ammunition Foreman, or Surveillance Inspector will furnish the ammunition designer, through appropriate channels, the data which he collects regarding the good and bad behavior of ammunition in transportation, storage, or actual use, he will aid materially in the improvement of ammunition. Much therefore depends on the completeness of reports received from the field as to whether or not future ammunition shall have incorporated in its design the fullest experience of Field Service.

Class of '26, U. S. Military Academy, Visits Frankford Arsenal and Aberdeen Proving Ground

Cadet William E. House, U. S. M. A., '26

Cadet William E. House, U. S. M. A.

EACH spring for the past twenty-five years the graduating class of the Military Academy has been taken on an observation trip under the auspices of the Department of Ordnance and Gunnery for the purpose of inspecting certain ordnance activities. The object is to teach something about the research and manufacturing carried on by the Ordnance Department of the Army. This year the trip lasted from April 24th to 28th, inclusive, during which time the class was at Frankford Arsenal and Aberdeen Proving Ground.

For the last eight months we have been absorbing great quantities of the theory of ordnance. Many phases of the subject have seemed to us to be very abstract and not extremely necessary as a part of the technical training of the average line officer. So for many weeks we looked forward to the trip with a bit of suspicion, feeling that we were going to spend a few days listening to rabid theorists expounding their dry and intricate doctrines. We understood that otherwise the journey would be very pleasant and entertaining, so we discounted the theorists before we met them in their native haunts. A holiday always has great appeal for a cadet and attendant discomforts are made the best of and forgotten as soon as possible, leaving only the brighter spots to linger in the memory.

Much to our great surprise, the theorists failed to materialize. In any event, they were so thoroughly disguised that we failed to recognize them. Instead we saw on every hand men who were apparently entirely practical and who were merely combining common sense with technical knowledge. We saw our old bugbear, Ballistics, treated with seeming contempt and forced to expose his secrets through the medium of tangible and understandable tools and equipment. Other equally respected "Unknowns" were found turning somersaults and "playing dead" at the command of mere men. So we proceeded to lose much of our awe for theory, while our respect for practical methods increased immeasurably.

The First Class, less those on leave for the week-end, proceeded by special train from West Point to Frankford Arsenal on Sunday, April 24th, arriving just before supper. The men on leave came in during the evening, all being required to report by midnight. We were quartered in barracks and messed at a nearby Post Exchange cafeteria —against which we shall most certainly enter no complaints!

Early Monday morning we lay abed listening to reveille —a most unusual procedure for cadets—and shortly after appeared at our temporary mess clamoring for breakfast. After we had done our best to satisfy our miraculously grown appetites (they are never exceptionally small) the official day was begun by an address by Col. O. C. Horney, Ord. Dept., U. S. A., Commanding Officer of the Arsenal. Beginning with a most cordial welcome, he outlined our work for the day and gave us a brief resumé of the operation of the arsenal. Then the class was divided into groups

West Point Cadets Watch Mobile Artillery Demonstration, Aberdeen Proving Ground.

Class of 1926, U. S. Military Academy, at Aberdeen Proving Ground, April, 1926.

of fifteen and turned over to the men who were to act as our guides.

It would require considerable space to give a very detailed account of our inspection of the shops, and perhaps such a narration of our day would not be particularly interesting. So we will confine ourselves to a few passing remarks. One thing which stands out vividly in the writer's memory is the visit to the power plant. In the midst of an explanation of the feed-water system, we were told some of the most amazing fish stories possible. To fully appreciate these tales of how three-foot fish pass through screens and valves, not to mention pumps, one must hear them first hand.

At each point in our tour we were given short lectures on just what was accomplished at that place. Or else the purposes of special instruments, such as sound ranging devices, for example, were shown together with explanations of the underlying principles. There was every opportunity to gain useful as well as entertaining knowledge.

Early Tuesday morning we entrained again and started for Aberdeen Proving Ground. Somewhere along the road we carelessly lost a "day-light" hour, so we arrived at our destination not very long after we started. As soon as our bags had been left at the Guest House we were marched to the Headquarters Building to begin the second phase of our trip.

After a brief introduction by Major MacFarland, Professor of Ordnance and Gunnery at the Military Academy, we were addressed by Col. C. M. Wesson, the Commanding Officer of the Proving Ground. His welcome was every bit as cordial as Colonel Horney's had been, and was followed by a talk on the work at Aberdeen and the things that we would be shown.

Again we were divided into small groups and started on a schedule which ran like clockwork.

In the instrument building we witnessed the operation of the Aberdeen chronograph and other instruments for collecting data. At the museum we saw the different types of automotive equipment and artillery which have been collected there. And so through the day, new wonders being discovered at every turn. One of the most interesting spots visited during the day was the main front, where we saw several new types of artillery and small arms and met for the first time the caliber .50 machine gun and the automatic 37-mm. gun. At this point, also, were several types of automotive matériel, from a Mark VIII tank to cross-country cars. We were allowed to ride in all of these and even to drive some of them, to our great delight. Many unexpected thrills were experienced but no casualties were suffered, fortunately.

After a leisurely dinner at our quarters we returned to the main front just at dusk to witness night firing. Tracer bullets filled the air, mechanical time fuzes set off shrapnel at the proper instants, and flashless powder refused to flash. From now on we will believe anything. If we should be told of a new type of propelling charge which does not even require a gun to send a projectile fifty miles without flash, smoke, noise, or other disturbance, we will accept the statement without proof, feeling that the Ordnance Department can accomplish anything.

After the firing we were met by a more familiar sort of night problem. The officers and ladies of the post had arranged a reception and hop for us at the Headquarters Building and, since it was what we call a "feed hop," even the most confirmed stags were happy.

Wednesday morning we again became interested observers—this time at the plate range. Just to make the trip complete, the usual group picture was made of the class doing its best to hide the sixteen-inch barbette mount. Formalities over, the firing proceeded, beginning with a mighty round from the fourteen-inch disappearing gun. Fortunately we did not all watch the same detail so that later discussion enabled us to gain complete pictures of the guns in action. An eight-inch howitzer on railway mount next barked for us and then we watched a three-inch antiaircraft gun trace its trajectory across the murky sky by means of shrapnel timed at varying intervals.

At noon we boarded our special for the last time and began our long ride back to West Point. *En route* the usual informal and unofficial critique was held, ending in a unanimous opinion that we had learned a lot and had had a really wonderful time. In fact, the effect of the trip was so great that several prospective second lieutenants have been heard to ask about ways and means of being detailed to the Ordnance Department—and no greater compliment could be given.

Editorial

Picatinny Arsenal, 1880-1926

WITH but forty-six years to its credit, Picatinny is the youngest member of the family of manufacturing arsenals. But wars accelerate very greatly the development of all of the elements of the Ordnance industry, and Picatinny is no exception to the rule.

The rapid rise in the relative importance of ammunition in the last two wars in which our nation has participated called for an ammunition establishment with facilities and personnel to cope with the multitude of problems related to the manufacture, storage and use of ammunition.

Beginning as a powder storage depot, the Arsenal has been given additional ammunition responsibilities from time to time until it is now recognized as the headquarters of the Ordnance Department's organization to control the manufacture and care of all types of ammunition except the cartridges for small arms.

The manufacturing capacity is limited when compared to the tremendous artillery ammunition and bomb requirements in time of war, but in peace and during the early months of a war, Picatinny products appear as an appreciable portion of the total production. However, Picatinny's principal product at any time is knowledge of the arts and sciences involved in the manufacture and technical use of ammunition. The training of Regular and Reserve Officers and civilians to fill positions of responsibility in the organization of the Ordnance Department in both peace and war will call for considerable effort on the part of our ammunition arsenal. What task is more important than that of perpetuating the knowledge of the ammuntion industry in this great nation? How well Picatinny is prepared to fulfill this mission we leave to you to decide, and if your decision calls for constructive action on the part of anyone will you help the cause along by doing what you can directly or indirectly to hasten the development of an ammunition arsenal fully equipped and manned which no one will ever "view with alarm," but to which all "will point with pride."

Complete Rounds

"THE round's the thing," to paraphrase a more classic but not more important quotation. It's all very well to talk about fuzes and cartridge cases and primers and powder charges and the rest, but as in every other assembled unit all parts of the complete round of ammunition must be viewed in their relation to the whole. True enough the complete round depends for its ultimate perfection upon the development and manufacture of the best components, but even these are "best" only in as far as their development affects the utility and perfection of the complete round.

While giving a composite view of Picatinny Arsenal and the important development and manufacturing activities conducted there, the articles in this issue of ARMY ORDNANCE must bring one to an understanding of the necessity of thinking of ammunition in terms of the complete round. The watchmaker, concerned as he is with the quality of the escapement mechanism, or the number and kind of springs he has on hand, and hundreds of other factors, must always look to the complete article, because it is just that he will sell to the consumer. The manufacturer of automobiles, interested as he is in carburetor, transmission, motor, ignition and every other individual component entering into his vehicle, keeps ever before him the complete product because it is just that and the quality of it that makes its appeal and utility to the user.

Now the complete round of ammunition differs little, if any, from these and similar products, and the sooner all of us—in the service and out, manufacturer and engineer, industrialist and officer—think of ammunition in these terms so much the sooner will a working understanding and a better realization of the importance of the subject be common to all of us.

When ammunition is needed it is generally needed badly—statistics have been quoted time and again to prove that this is so. In battle the battery commander cares little whether there are so many mark so and so shells without boosters and mark so and so projectiles without fuzes. He must have complete rounds, and it is a part of the Ordnance job to see that he gets them.

Thus does the problem of industrial preparedness mount higher and higher, for there are few plants indeed that can ever hope to produce ammunition in complete rounds. But the actual design and production of the round, who will manufacture this component and who that, are all Ordnance matters which accurate and persistent planning will accomplish. The thing is that the user requires the complete round and it is therefore essential that we think in terms of complete rounds, keep the round as a unit ever predominant and see to it that the round as issued is the best that our engineering skill, manufacturing equipment and storage and issue facilities can turn out. The complete round is the culmination of the ingenuity of many minds, the fruition of many manufacturing processes and the result of much handling, storing, and observation—and everyone of a thousand steps in its creation must be faultlessly accurate and as near perfect as is humanly possible. And it is the complete product that must function else all that has gone before is no avail.

Therefore, the round's the thing—the best round that can be had—delivered ready for use at the gun. It is only in this light that ammunition takes its real place of importance in the catagory of ordnance. A shell without a fuze or with an imperfect copper band, or any other defect,

is time and money lost; but a gun without its complement of complete rounds becomes just so much metal and is as useless for its mission as the human body without life. "The round's the thing."

Reserve Officers

THE old bromide of a million men springing to arms over night never did receive much serious thought from thinking men. Patently there must first be the arms to spring to and, equally obvious, given the arms it is a rather difficult overnight "spring." A few short years have not erased the memories of training camps and cantonments with their hundreds of thousands training for weeks and months in a feverish endeavor to master the mere rudiments of the science of battle.

But this is a twice-told tale. To recall it does not convince in the slightest those who are not open to conviction. Unfortunately we have a very insidious group of thinking men among us, however, whose prime purpose is to discourage military training in our schools and thus kill at the root the dominant idea of our present system of national defense. Like all other enemies within the gates they are a pretty shrewd lot. Regardless of their aversion for facts, their avoidance of logic, their brazen effrontery of the principles that have made us what we are, they have the uncanny ability and persistent boldness to strike telling blows at our military training system and already they have scored at least partial victories here and there.

It is not our purpose to enter into a diatribe against pacifists and pacifism. There are some conscientious objectors whose convictions are sincere; with these we have no quarrel; they do not constitute the menace. The enemy within the gates is rather that subtle organized body which is bending its whole effort at the destruction of our present military system by blighting the very foundation of our civilian training. It may be that one of the results of our modernist, utilitarian age in its throwing over the principles of days past is to shirk the responsibilities of defense. The days of the swarthy pioneers are gone and with them a rugged honesty and fearlessness, a sense of duty and willingness to share in the responsibilities as well as the rewards of nationhood.

But we digress, to get back to the necessity for military training, let us consider only the Reserve Officer plase of the subject. Almost eight years have passed since the command, "Cease firing" was given and since then our only replacements in the ranks of the organized reserves are coming from graduates of the Reserve Officers' Training Corps. It will not be long before those who served in the World War will have passed on and then experienced men will have turned over the task to a rising generation to whom the lessons of that conflict will have no more intimate meaning than have the lessons of Valley Forge and Gettysburg for us of today. Certainly these lessons are great in themselves but they lack the influence of the men who took part in them to make their results more real. And so it is with those who took part in the World War. Today we can listen to their descriptions of the problem and their efforts toward a solution. Commanding generals are with us to recount their experiences, officers who played only minor roles can give us the results of their endeavors. Tomorrow the role will fall to other hands and as they are prepared well or ill so also will the path to victory lie.

Therefore, to nullify, or attempt to nullify, our efforts for a well-trained Reserve Corps, is to do inestimable harm to an important element of the Army. A skeleton Regular Army and a fit National Guard are not enough. In the wisdom of those who planned the National Defense Act the third element is also vital. Our triune military organization requires a Reserve Corps ready and prepared to assume its assigned task. Today the Reserve Corps comprises a body of patriotic individuals who, cognizant of its value and importance are willing to give of their time and effort that they may play their parts to the best of their ability. He who restricts the replenishments of the Reserves by throttling the Reserve Officers' Training Corps is guilty of serious attempt to harm an organization that is by far the best balanced and most effective one we have yet tried.

PICATINNY WRECKED

AS this issue of Army Ordnance goes to press Picatinny Arsenal is a mass of wrecked buildings and equipment. On July 10th the Naval Ammunition Depot at Lake Denmark, N. J., located scarcely a half mile from Picatinny, was utterly destroyed by a series of explosions which wiped out the huge naval establishment. The resulting damage to Picatinny can scarcely be estimated. All buildings are wrecked, the chemical laboratory a mere shell of walls, the power plant razed, administration building demolished and the powder factory, loading area, pyrotechnic section and testing groups a tangled mass. What the approximate damage to the organization, plant and equipment at Picatinny is cannot be estimated at this writing.

A sterling officer of great promise, 1st Lieut. George W. Bott, Ord. Dept., U. S. A., was the only member of the Picatinny personnel to lose his life. All officers and their families at the post at the time were injured and their quarters demolished. To the injured Army Ordnance extends its heartfelt sympathy.

But the Picatinny disaster could have been far more serious. Had the blow come during working hours when some 600 civilian employees would have been in the various plants the loss of life would have been staggering.

Thus this issue of Army Ordnance which was intended to describe the ammunition arsenal, its splendid record of accomplishment and its facilities for future progress becomes rather a memorial to an establishment that has suffered a severe blow.

But from this wreckage let us plan an even greater Picatinny that will carry on where the present demolished establishment left off. Let us hope that funds will be immediately appropriated to begin the gigantic task of salvage and reconstruction so that the loss to the Army and the nation may be minimized as much as possible.

Historical

Edited by Maj. William A. Ganoe, Inf., U. S. A., Historical Section, Army War College.

Kunckel's Discovery of Fulminate

TENNEY L. DAVIS

AFTER the first use of black powder in a gun, more than five centuries elapsed before anything fundamentally new came into the explosives art, before the principle of the high explosive was discovered and applied. Substances now became available which, like nitroglycerin, were exploded by unintentional shock or were made to burn by fire without exploding, which were uncertain and unpredictable in their action. Others, like picric acid, were incapable of exploding from fire or from ordinary shock. It was found that these substances could be exploded regularly by the shock which resulted from the explosion of a small quantity of mercury fulminate. This primary explosive or "initiator" would explode from fire, invariably, whether confined or not, and the great local shock which it would produce would initiate the explosion of the high explosive. The discovery of the peculiar properties of mercury fulminate showed that high explosives were possible. Its use made them tractable.

The preparation of fulminating gold and silver by the action of ammonia on the salt of the corresponding metal is described in what purports to be the writing of Basil Valentine, Dominican monk of Erfurt, in the early part of the fifteenth century. These writings are spurious, for there has never been a Dominican monastery at Erfurt and the records of that religious order do not contain the name of Basil Valentine. They were evidently written in the late sixteenth or early seventeenth century by Johann Thölde (or Thölden) of Hesse who first published them, and constitute altogether an excellent summary of the best chemical knowledge of the time, collected without acknowledgment of source. Fulminating gold and silver were perhaps discovered by the Dutchman, Cornelis Drebbel (1572-1633). Their composition does not yet appear to have been definitely settled, for they are difficult substances to handle and explode on very slight provocation. For a time after their discovery they attracted considerable attention as toys or chemical curiosities, but they have not been put to practical use. In his diary for November 11, 1663, Pepys describes a conversation with a Dr. Allen who told him about *Aurum fulminans*, "of which a grain—put in a silver spoon and fired, will give a blow like a musquett and strike a hole through the spoon downward, without the least force upward."

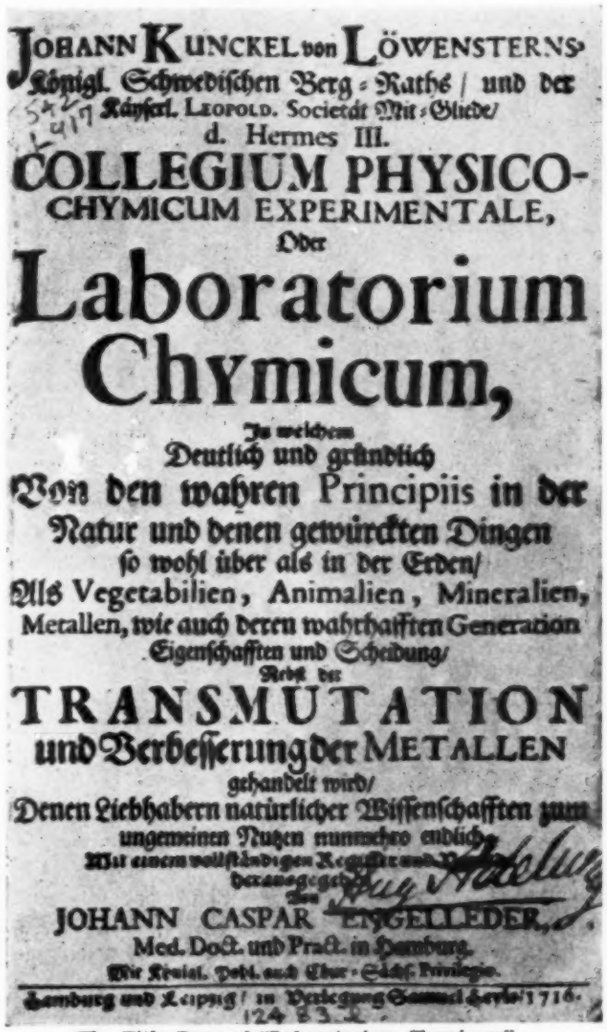
Johann Kunckel, (1630-1703).

The striking properties

of fulminating gold and silver attracted the attention of Johann Kunckel (1630-1703) and led him to the discovery of fulminate of mercury. This man was an exceptionally able experimenter and an acute observer, and contributed many new facts to chemistry. He is best known for his studies on ruby glass and on phosphorus. He was employed by various German princes and finally by Charles XI of Sweden by whom he was made Baron von Löwenstern and Counsellor of Mines for the kingdom. His most important work, the *Laboratorium Chymicum*, was published after his death, under the editorship of Engelleder. On pages 213-214, he says:

"Further evidence that Mercury is cold is to be seen when you dissolve it in *Aqua fortis* (nitric acid), evaporate the solution to dryness, pour highly-rectified *Spiritum Vini* (alcohol) over the residue, and then warm it slightly so that it begins to dissolve. It commences to boil with amazing vigor. If the glass is somewhat stopped up, it bursts into a thousand pieces, and, in consequence, it must by no means be stopped up. I once dissolved Silver and Mercury together in *Aqua fortis* and poured over it an excess of *Spiritum Vini*, and set the mixture to putrify *in fimum Equinum* (horse manure) after having stopped up the glass with mere sealing wax only. When it happened a few days later that the manure became a little warm, it made such a thunder-crack, with the shattering of the glass, that the stable-servant imagined, since I had put it in a box, either that someone had shot at him through the window or that the Devil himself was active in the stable. As soon as I heard this news, I was able easily to see that the blame was mine, that it must have been my glass. Now this was with Silver and Mercury, 2 *loth* of each. Mercury does the same thing alone, but Silver not at all.

"No *Fulmina* are produced unless hot and cold come together and have an wholly subtle earth between them. Now Mercury consists for the most part of such a *Terra viscosa* (viscous earth), for otherwise it would have remained water, and it is therefore called also a dry water which does not moisten the hand. Likewise all *Fulmina* which are made artificially must have such an earth, as is seen in the case of fulminating gold, and fulminating Mars, Moon, and Saturn (iron, silver, and lead), which all must be precipitated with a *frigidus* (cold), like *Salt of Urine* (ammonia), C. C. (*cornu cervi* or hart's horn, i. e., ammonia), etc., or otherwise they give no *fulmen*."


JOHANN KUNCKEL von LÖWENSTERN,
Königl. Schwedischen Berg-Raths / und der
Käyserl. LEOPOLD. Societät Mit-Gliede/
d. Hermes III.
COLLEGIUM PHYSICO-
CHYMICUM EXPERIMENTALE,
Oder
Laboratorium
Chymicum,
In welchem
Deutlich und gründlich
Von den wahren Principiis in der
Natur und denen gewürckten Dingen
so wohl über als in der Erden/
Als Vegetabilien, Animalien, Mineralien,
Metallen, wie auch deren wahrhafften Generation
Eigenschafften und Scheidung/
Nebst der
TRANSMUTATION
und Verbesserung der METALLEN
gehandelt wird/
Denen Liebhabern natürlicher Wissenschafften zum
ungemeinen Nutzen nunmehro endlich
Mit einem vollständigen Register und
herausgegeben
Von
JOHANN CASPAR ENGELLEDER,
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Mit Königl. Pohl. und Chur-Sächs. Privilegio.
Hamburg und Leipzig/ in Verlegung Samuel Heyls/ 1716.

The Title Page of "Laboratorium Chemicum" by Johann Kunckel.

This astonishing experiment no doubt became one of the standard exhibits of street fakirs and mountebanks, along with Kunckel's phosphorus. Liebig, who was born in 1803, saw a fakir prepare and exhibit fulminate of mercury in the market-place at Darmstadt when he was a boy. He watched the process with interest, recognized by its odor the alcohol which was used, went home, and succeeded in preparing the substance for himself. In 1823, when he was working with Gay Lussac at Paris, he studied the fulminates and isolated fulminic acid.

Silver fulminate, as Kunckel says, is not produced by pouring alcohol alone onto silver nitrate. Brugnatelli, however, prepared it later by pouring onto one hundred grains of powdered silver nitrate, first an ounce of alcohol, and then an ounce of concentrated nitric acid. After the fulminate had precipitated, the mixture was diluted with water to prevent it from dissolving again, and immediately filtered.

Edward Howard, who described the preparation of mercury fulminate in a paper before the Royal Society of London in 1800, has generally been regarded as the discoverer of the substance. He dissolved mercury in warm nitric acid and poured the solution, after cooling, into alcohol. This mixture was then warmed to excite effervescence, and filtered for the removal of fulminate as soon as precipitation appeared to be complete. Howard's method is essentially the method which is now in use on a factory scale. The use of fulminate caps for priming the black powder charges of muskets soon came in. Sixty years elapsed after Howard's paper before the observation was made by Alfred Nobel and his father that nitroglycerin could be detonated by means of fulminate. After that, the development of high explosives was rapid.

Theater of Operations

Edited by Maj. T. A. Clark, Field Service, Office of the Chief of Ordnance

ORGANIZATION

IN THE last two issues we touched upon the Commander and his assistants—the General Staff and the Technical, Supply and Administrative Staff. We may liken the commander to the driver of a car. The ultimate object of the operation of the automobile is to displace the driver through distance. This displacement is accomplished by the exertion of force in overcoming the resistance of weight (gravity), internal friction, road friction and wind. So the general object of the commander of an army is to advance, and he does so against this resistance of the enemy and against the internal resistance of his own military machine. The brain or ego of the driver represents the commander, his hands and feet are his staff and the engine and accessories his troops. Now the parts which go to make up a car, if scattered around the floor, do not constitute an automobile. Each part in itself is capable of performing its function but there is something lacking—organization. The impulse of mechanical organization is design. The designer starts with an analysis of the forces to be overcome and he computes both the strength of the parts and their inter-arrangement; some certain parts must operate numerous others, and these certain parts in turn are governed or directed by some central part and so on—until we get up to the throttle lever, a touch of which directs the operation of the entire machine. A carpenter contracting for a small frame building can keep the few necessary workmen under his own eye and give them directions personally, but when he becomes a large contractor, building huge and numerous structures, his workmen must be organized—foremen are employed who handle a certain number of men according to the resistance of the problem, and these foremen are, in turn, under a manager who reports to the contractor.

Organization is the first problem confronting any commercial manager handling any proposition requiring a large personnel. So it is with the military problem. The military resistance to be overcome is analyzed and the forces to meet it are organized in accordance therewith. Military resistance includes not only the resistance of the enemy but the internal resistance of the military machine itself—administration, discipline, marching, camping, immobility, etc. Hence when we consider the present organization into companies, regiments, brigades, etc., we know that these bodies of troops are not parcelled out arbitrarily merely to form a chain of command, but that they are based upon long experience with military resistance. The fact has been determined that a corporal of infantry on the firing line and in training can best handle about seven or eight men—hence the first element of organization, the infantry squad. Thus a platoon commander can control so many squads—a captain so many platoons, and the commander of a battalion, which is the smallest independent fighting unit, so many companies. Thus far we have considered only the fighting resistance. Into such organizations as companies, regiments and divisions enters the problem of administration, and in the division and the army the problem of supply. The division is the basic large combat organization and includes all arms except cavalry. It is based largely on mobility; it is the largest self-sustaining and self-supporting unit that, marching in one column, can close on its head for combat or for bivouac in one day. A division may seize and hold a part of a general line temporarily but cannot drive through to a decision. The line must be extended or the action reinforced by other divisions. In order to retain control (chain of command), divisions are organized into corps.

Artillery is organized according to the amount of infantry needing artillery support—thus a brigade of light artillery ordinarily supports a division of infantry, a regiment of artillery a brigade of infantry, and a battalion of artillery a regiment of infantry. A regiment of corps artillery (medium artillery) is of sufficient size to support a division of infantry, but it is not *assigned* to the division as an integral part because it would restrict the mobility of the latter. After the divisions of the corps are in line the corps artillery is normally brought up and an artillery regiment given the temporary duty of supporting a division of infantry. Thus the factors of infantry support (artillery fire power) and mobility as well as administration and chain of command enter into the organization of artillery.

When units are grouped into a division certain additional troops are needed for special services and administrative purposes. In the division these are grouped together under the title of Special Troops. The Ordnance Maintenance Company is in this group.

The motive of corps organization is a trifle different. There is first effected a skeleton organization or framework consisting of Corps Headquarters and Staff, and of "Corps Troops" consisting of service, supporting and supply troops, and to this framework are added as many divisions and army supporting troops as are necessary to carry out the particular mission in view. One branch of the corps troops is the "Corps Special Troops" which in-

cludes two ordnance companies, one heavy maintenance and one ammunition, which serve the corps at large, while another branch of the corps troops, the "Corps Artillery," includes one ordnance company maintenance primarily for service of the artillery brigade.

The army organization consists of a heavy skeleton composed of "Headquarters" and of "Army Troops" of all arms and services. To this framework are added as many organic corps as are necessary for a particular task. The army is primarily a supply organization and the "Army Ordnance Service" contains several ordnance supply (ammunition and depot) companies.

General Headquarters administers the theatres of operation and holds in reserve large quantities of artillery, tanks and so on—to be attached temporarily to armies for their support in particular missions, after which the matériel is withdrawn. This reserve is called the "G. H. Q. Reserve." G. H. Q. artillery, tanks and air service are organized into units with a pro rata of ordnance maintenance companies. The G. H. Q. ordnance includes several ordnance supply companies for use in rear of the army areas and in the communication zone.

Below is a summary of organization in the theater of operations with reference to ordnance companies:

Division
- Special Troops
  - One Ordnance Company, Maintenance.
    - Equipped to repair and furnish a limited amount of spare parts to the infantry and artillery weapons of the division.

Corps
- Corps Troops
  - Special Troops
    - One Ordnance Company, Heavy Maintenance, which takes on slower and heavier work than can be handled conveniently by ordnance companies farther to the front.
    - One Ordnance Company, Ammunition, has charge of the ammunition section of the corps park.
  - Corps Artillery Brigade
    - One Ordnance Company, Maintenance, normally accompanies the brigade and handles light repairs and replacements for the medium artillery. Heavier work of this brigade is passed back to the heavy maintenance company.

Army
- Army Troops
  - Army Ordnance Service
    - One Ordnance Company, Headquarters, furnishes personnel for administration of army ordnance service.
    - One Ordnance Company, Maintenance, specializes in small arms repair. It is assigned to Army Small Arms Repair Center.
    - Three Ordnance Companies, Ammunition, assigned to army ammunition depots.
    - Three Ordnance Companies, Depot, with army supply depots.
  - Army Cavalry
    - Two Ordnance Companies, Maintenance, equipped for service with cavalry and assigned one to each cavalry division of the army.
  - Army Artillery
    - One Ordnance Company, Maintenance, with the army antiaircraft brigade.
  - Army Air Service
    - One Ordnance Company, Maintenance, specializing in aircraft machine guns and bombs.

General Headquarters
- G. H. Q. Light Artillery
  - One Ordnance Company, Maintenance, per brigade, portee and motorized; pro rata, two per army.
- G. H. Q. Antiaircraft Artillery
  - One Ordnance Company, Maintenance, per brigade; pro rata, two for six armies.
- G. H. Q. Heavy Motorized Artillery
  - Two Ordnance Companies, Heavy Maintenance, per brigade; pro rata, two per army.
- G. H. Q. Ordnance
  - One Ordnance Company, Ammunition, per army, at ammunition supply depots.
  - Two Ordnance Companies, Depot, per six armies, at general supply depots.
- G. H. Q. Tanks
  - One Ordnance Company, Heavy Maintenance, per tank group; pro rata, one per army.
- G. H. Q. Air Service
  - One Ordnance Company, Maintenance, per heavier than air wing; probable pro rata, one per army.

The staff organization of Ordnance in the theatre of operations includes a Chief Ordnance Officer on the staff of the commander of the field forces, an Army Ordnance Officer, a Corps Ordnance Officer and a Division Ordnance Officer on the respective staffs of the troop commanders and other ordnance personnel in the communications zone. The functions and duties of ordnance personnel and companies will be discussed in future issues— the object of this issue is to bring out the purpose of organization. The subject is a large one and the attempt here is merely one of analysis and of orientation of the Ordnance elements in the military machine.

Although mobilization is a function of the zone of the interior yet most ordnance companies are destined for the theatre of operations and the subject of their local mobilization is ever an engrossing process. Reserve Officers have taken much interest in this process and with their experience in civil life are in a good position to contribute many valuable suggestions to the solution of the problem of local mobilization. Below is a paper prepared and read by Capt. George Paul Slade, Ord. Res., at a local meeting of Reserve Officers in Boston, Mass., May 6, 1926. Captain Slade is to be complimented upon his zeal and grasp of the problem. It is suggested as an interesting study to other Reserve Officers that each imagine himself given the task of the mobilization of an ordnance company in his community and that he make a survey of local resources with a view to determining the best point for rendezvous and training.

War Planning As Applied to Ordnance Units

Capt. George Paul Slade, Ord. Res.

I HAVE been asked to speak on War Planning as Applied to Ordnance Units. I hope you will not look on what I may say as any attempt to give the last word on this subject, but rather as making certain suggestions which may lead to a more extended study and consideration of the subject.

I suppose Ordnance Units include maintenance companies, depot companies and ammunition companies, as well as headquarters and proving ground companies. The commanding officer of Ordnance Units has a wide variety of duties. He must provide for the food, clothing, shelter, physical and spiritual welfare and training of his men. He must also see to the procurement, inspection, storage, maintenance and issue of ordnance matériel. With the different kinds of units, the functions differ, but there are certain considerations which apply to all units.

The first considerations, both before mobilization and immediately upon mobilization, will be those of personnel. In organizing the unit in peace time, high grade men should be sought for the commissioned and enlisted personnel. In the maintenance company particularly men of varied experience should be obtained, so as to have an organization ready to meet whatever demands may be made upon it. In peace time personnel should be trained to the fullest extent which the availability of funds and the interest displayed by the personnel will permit. Periods of active duty training are of course most useful. Correspondence courses do their part. And occasional meetings should be held through the winter months at which subjects of interest to the unit should be taken up.

Immediately upon the outbreak of war, intensive efforts should be made to complete the authorized peace time *cadre* of the unit. Personnel already assigned to the unit should be requested to interview men known to them and having the desired qualifications. For depot and ammunition companies, the local warehouse concerns and wholesale houses should be canvassed for proper personnel. For maintenance companies, local machine shops, manufacturing concerns, automobile service stations and engineering societies should be canvassed. If funds can be made available, it might prove advisable to insert advertisements in the local newspapers.

Warning orders and orders calling officers and enlisted men to active duty should be all prepared except for the dates to be inserted in them, and these orders should be sent out immediately upon receipt of similar orders by the unit commander.

Plans should be made to care for the personnel immediately upon mobilization at the rendezvous point. It is believed to be the intention to send certain units to arsenals or proving grounds for training just as soon as they are mobilized. But—orders have to be issued, transportation facilities have to be made available, and what with one thing or another there is pretty sure to be *some* delay. It is therefor absolutely necessary to plan to care for the personnel locally for at least a certain length of time.

One of the first considerations will be shelter. In many cases it will be possible for all the men of a unit to sleep at home, reporting each day at the rendezvous point. This will not always be possible, however, and if the unit is apt to remain at the local point for any length of time, it probably will be preferable, for the purposes of discipline, and for organizing and training the unit, to have all the men quartered in one central place. It would seem advisable in peace time to arrange for at least one specific place for a barracks. If possible, the owner of some certain property should be made to give the first right of occupation of a place to your particular unit. This, of course, without obligating the government to utilize that place. It should be borne in mind, that your unit may be mobilized at a different stage of the mobilization proceedings from that at present contemplated, and if possible you should therefore secure the first right to use such premises at any and all times. At this point let me remark that in your planning it would seem advisable to allow yourself the greatest leeway for all situations that may arise. All plans should be very elastic. You may find it necessary to discard most of your planning and start anew.

It will probably be impracticable to start a company mess while at the local barracks. Arrangements will therefore have to be made for a nearby restaurant or boarding house to furnish meals. Such arrangement would be definitely made only after competitive bidding so as to insure protecting the interests of the government. But in making your mobilization plan, existing restaurants and boarding houses in the neighborhood of the designated barracks should be carefully noted. In seeking competitive bids, sample menus as set forth in the manual for Army cooks should be furnished prospective bidders, and the bidding and awarding of the order will be conducted in accordance with the Army Regulations on the subject.

Immediately upon mobilization and while awaiting transportation, intensive training should be carried on as far as personnel and facilities available will permit. It may be that facilities for the technical training of a unit will not be readily available. In this case military training may be emphasized while the unit is at the local barracks. It is believed to be the policy of the Ordnance Department to train all field units in defensive tactics. Closed and open order drill should therefore be given. This means that in time of peace you should locate some suitable area near the chosen barracks which can be used as a training field. Local pistol and rifle ranges should be located and their availability for use in time of war determined. Insofar as technical facilities can be made available, technical training should be given. Depot and ammunition companies should make arrangements with local warehouses or wholesale concerns for a study of their methods of handling and storing various kinds and shapes of articles, and also their systems of records. Maintenance companies should study such ordnance matériel as may be available, as in state armories or with national guard or other reserve units, and it might prove advisable to give the personnel broader experience than they had had on their particular kind of machine shop or assembling work by uti-

lizing such facilities as could be made available. In the Northern States provision should be made for use of an enclosed drill-hall as mobilization might take place during the winter months. Subjects in which training is to be given should be considered, and it seems wise in peace time to work out training schedules, including a list of calls for the daily conduct of the company. The duties of the Officer of the Day and of the non-commissioned officer in charge of quarters should also be planned.

In training the members of the *cadre*, they should be trained with a view to teaching them to become instructors themselves. They should be taught the necessary steps to receive increments of drafted men and to train the drafted men in their duties.

There is a considerable quantity of paper work to be accomplished when a unit is mobilized. All members of the *cadre* and especially those who will have the military administration of the company as their chief work, should be thoroughly trained in peace time in the paper work which they will be called upon to accomplish.

Tables of Organization for some of the larger ordnance companies provide for a medical officer and medical enlisted personnel to be attached to the company. Where army medical personnel is available, it should be used for the initial physical examinations and for the care of the sick. Otherwise arrangements should be made, according to Army Regulations, with civilian doctors and hospitals for the care of the sick. At training camps medical facilities will probably be provided by the camp authorities. If any personnel has to be left in some local hospital when the *cadre* moves to training camp, the local reserve office, or else corps area headquarters, and the man's nearest relative should be advised of the arrangements made for his care, and the nearest Army office should be requested to maintain supervision of the case.

Sanitation regulations at the local barracks will very likely fall on the company commander, as medical personnel to advise on this subject may not be available. Scrupulous personal cleanliness and cleanliness of quarters should be insisted on at all times. Regular inspections should be made. Proper sanitary regulations to fit the particular situation should be carefully considered.

Activities to occupy the attention and spare time of the men should be organized. At the local barracks the men will be largely in their home environment and can be depended upon to take care of themselves. But once away from home athletics should be encouraged, reading and writing rooms should be provided, and entertainments should be gotten up especially among the men themselves. Opportunities should be furnished for the men to attend church. Every effort should be made to provide wholesome diversions for the men in their spare time.

A matter which should be considered while the unit is at its local barracks and perhaps even before its mobilization is that of starting a company fund. Entertainments, dances and fairs should be planned and carried out with a view to increasing the company fund. It will probably be advisable to organize a ladies auxiliary to assist in developing this fund and to supply knitted goods and other accessories or luxuries.

Supply requirements while at the local barracks should be kept at a minimum. They will consist mostly of office supplies and cleaning equipment. Shelter and mess equipment will not be required, as this will be furnished locally by contract. The men will probably use their civilian clothing while at local barracks. Absence of some equipment will mean an easier task in moving the *cadre* to the training camp.

Two of the enlisted men of the *cadre* should be chosen to report any enemy or pacifist tendencies observed in any member of the company. Relations with the public and the press should be observed and regulated by the company commander.

I have only been able to touch on the broad outlines of this subject. Details will need to be worked out to fit each unit and local conditions.

In closing may I remind you that war planning and training is the very substance of the Reserve Corps idea. Let's get into it with enthusiasm. Let's put our time and energy on this subject and have a highly organized and highly trained Reserve Corps that will satisfactorily handle and quickly dispose of *any* emergency that may arise.

THE EIGHTH ANNUAL MEETING

of the

ARMY ORDNANCE ASSOCIATION

ABERDEEN PROVING GROUND, MD.

October 8, 1926

Professional

The Explosive Properties of the Silver Salts of Some of the Nitro-Aromatic Compounds and Silver Oxalate

THE detonating properties of silver azide[1] and silver fulminate[2] have been discussed in previous articles in this series of studies on silver initiators. Our results on silver picrate, silver trinitroresorcinate, silver oxalate, and the silver salt of hexanitrodiphenylamine are presented in this article[3].

Silver Picrate

Chevreul[4] made silver picrate in 1809; Liebig[5] noted that it explodes on being heated; Post and Mehrtens[6] investigated some of its properties in 1875; and Silberrad and Phillips[7] established its formula as $AgC_6H_2O_7N_3$ in 1908, and stated that it explodes feebly at 336-344°C.

Preparation

Picric acid was dissolved in the least possible quantity of boiling water and an equivalent molecular weight of silver oxide was added. The silver oxide went into solution readily with stirring. Silver picrate crystallized out on cooling the solution. It was filtered off on a suction filter, washed with water, and dried. The yield was about 99 per cent of the theoretical.

Properties

The silver picrate obtained consisted of a mass of fine yellow needles which crushed readily when dry, melted and decomposed slowly at 315°C., and exploded at 335°C. It exploded weakly when brought in contact with a flame but was not ignited or detonated by the spit of a fuze when compressed in a detonator capsule. Charges of 0.4 gram pressed in detonator capsules were detonated by a minimum weight of 0.18 gram of mercury fulminate when confined by a reinforcing cap. Charges of 0.4 gram of TNT required 0.24 gram of mercury fulminate, confined as above described, to detonate it; but this TNT charge crushed 10 per cent more sand in the sand-bomb test than the silver picrate charge did. Silver picrate exploded by the drop of the 500-gram weight through a height of 577 mm. in the impact test.

The solubility of silver picrate at 25°C. is as follows per 100 grams of solvent: in water, 1.61 grams; in ether, 0.019 gram; in acetone, 3.117 grams; and in 95 per cent alcohol, 0.978 gram.

1. Taylor, C. A. and Rinkenbach, Wm. H., Army Ordnance, vol. v, 1925, pp. 824-5.
2. Taylor, C. A. and Buxton, E. P., Army Ordnance, vol. VI, 1926, p. 302.
3. Published with approval of the Director, Bureau of Mines.
4. Chevreul, M., Action of nitric acid on indigo. Ann. Chim. Phys., (1) vol. 72, 1809, p. 113.
5. Liebig, J., Poggendorff's Annalen, vol. 13, 1828, p. 191.
6. Post, J. and Mehrtens, H., Physical and chemical properties of salts of nitrophenols. Berichte, vol 8, 1875, p. 1549.
7. Silberrad, D. and Phillips, H. A., Silver picrate. Jour. Chem. Soc., vol. 93, No. 1, 1908, p. 477.

Silver Trinitroresorcinate

Böttger and Will first described[8] silver trinitroresorcinate as occurring in golden-yellow, palm-like crystal aggregates, for which they gave the formula $Ag_2C_6HO_8N_3.H_2O$.

Von Hemmelmayr obtained[9] small golden-yellow plates by treating a hot ammoniacal solution of trinitroresorcin with a solution of silver nitrate. Later he obtained brownish-red crystals by using more concentrated solutions than in the previous case. His analyses showed a silver content of 46.67 per cent for the yellow plates and 46.61 per cent for the brownish-red crystals. This indicated that each was the anhydrous form, which theoretically contains 47.03 per cent of silver.

Herz[10] patented a method for obtaining normal lead trinitroresorcinate which was investigated[11] in the Explosives Chemical Laboratory of the Bureau of Mines in 1923.

Preparation

In this investigation Herz' method was adapted to the making of the silver salt. Five cubic centimeters of glacial acetic acid was added to a boiling solution of 12.25 grams of 1,3,5 trinitroresorcin and 6.2 grams of $Na_2CO_3.H_2O$ in 640 cc. of water. After effervescence had ceased, a boiling solution of 34.0 grams of $AgNO_3$ in 80 cc. of water was added with stirring. A dense orange precipitate formed immediately. After cooling, the crystals were caught on a Buchner filter, washed with distilled water, alcohol, and ether, and dried. The precipitate obtained weighed 19.1 grams, as compared with a theoretical yield of 23.0 grams calculated from the trinitroresorcin used. The silver trinitroresorcinate contained 46.65 per cent of silver, as given by analysis.

A similar product was obtained without the use of acetic acid, but no precipitate formed when sodium carbonate was not present. When only sufficient Ag_2O to form a mono-silver compound was dissolved in an aqueous solution of trinitroresorcin, no precipitate was obtained. On adding sodium carbonate to this solution, a precipitate which proved on analysis to be the di-silver salt was obtained.

Properties

The solubility of di-silver trinitroresorcinate at 25°C. per 100 grams of solvent, is as follows: in water, 0.425 gram; in ether, 0.015 gram; in acetone, 0.074 gram; and in 95 per cent alcohol, 0.015 gram.

Di-silver trinitroresorcinate exploded by the impact of a 500-gram weight falling 460 mm. It exploded at 305°C.

8. Bottger, R., and Will, H., Annalen, vol 58, 1846, p. 298.
9. von Hemmelmayr, F. Monatschefte, vol. 25, 1904, p. 573, and vol. 26, 1905, p. 185.
10. British Patent 17,961, July 29, 1914. U. S. Patent 1, 443,-328, Jan. 23, 1923. Austrian Patent 5,492, June 26, 1914.
11. Taylor, C. A., and Rinkenbach, W. H., Preparation and properties of normal lead trinitroresorcinate, Reports of Investigations, Serial No. 2533, Bureau of Mines, Oct. 1923, 6 pp.

when dropped on the surface of hot metal, but decomposed at lower temperatures. It darkened slowly in sunlight.

Charges were weighed into No. 6 detonator capsules, compressed at 1,000 lb. per sq. in., and fired in the sand test bomb. The following table shows the weight of sand crushed as compared with that crushed by mercury fulminate:

Comparison of silver trinitroresorcinate and mercury fulminate

Weight of charge, grams	Sand crushed, grams by— Silver trinitroresorcinate	Mercury fulminate
0.100	0.7	2.4
0.200	1.8	3.4
0.500	3.2	15.3
1.000	15.4	35.0

SILVER OXALATE

Berthelot[12] states that silver oxalate explodes very energetically when subjected to a shock or when heated to 130°C. Wöhler[13] found that the salt exploded at 140°C. when heated in a current of hydrogen, which reduces the salt rapidly. Hoitsema,[14] however, gives an explosion temperature of 190°C.

Preparation

Silver oxalate was prepared by mixing cold solutions of oxalic acid and silver nitrate. An immediate precitation of a white solid took place. This was washed with water and dried. The same product was obtained both when the combining weights were used and also when either nitrate or acid was present in excess. Practically the theoretical yield was obtained. The products analyzed 70.52 to 70.71 per cent silver, compared with the calculated 71.00 per cent.

Properties

The silver oxalate made was insensitive to impact. It exploded with a weak puff at 260°C. when dropped on a hot metal surface at that temperature, and at 232°C. when heated slowly or after 30 seconds contact at that temperature. It was not ignited by the spit of a fuze when compressed in a detonator capsule, and was not detonated by 0.25 gram of mercury fulminate.

SILVER SALT OF HEXANITRODIPHENYLAMINE

Hantzsch and St. Opolski[15] state that the best method of preparation is by the action of silver oxide on hexanitrodiphenylamine in acetone solution. They then concentrated the solution by evaporation in a desiccator and precipitated out the product by the addition of absolute ether.

They describe the product as consisting of violet crystals slightly soluble in water, alcohol, and ether, but readily soluble in acetone. It turned dark at 190°C., decomposed at 200°C., and gave a silver content of 19.49 per cent as compared with the theoretical of 19.76 per cent.

It was found that the silver oxide, even though freshly prepared, did not go into solution or react in the acetone solution of hexanitrodiphenylamine; hence silver nitrate was dissolved in the minimum volume of water and added to the acetone solution. Then a solution of sodium carbonate was added, and a reddish yellow precipitate settled out. This was washed and then dried over H_2SO_4.

It was also made as follows: a concentrated solution 3.40 grams of $AgNO_3$ and sufficient NH_4OH to redissolve precipitated AgOH was added, with stirring, to a hot solution of 8.78 grams of hexanitrodiphenylamine in a mixture of 1800 cc. of water and 50 cc. of concentrated NH_4OH. Fine red crystals formed immediately. The solution was cooled and the crystals were filtered off on a Buchner funnel, where they were washed with water, alcohol, and ether. They were then dried over sulphuric acid.

Properties

Both of these products darkened at 190°C., decomposed below 200°C., and left a brown mass. They exploded weakly at 310°C. when dropped in a hot molten metal bath. Analyses gave a silver content of 19.52 and 19.57 per cent, which shows them to be similar to the product obtained by Hantzsch and St. Opolski.

Silver hexanitrodiphenylamine is not sensitive to impact, as it did not explode by the fall of the 500-gram weight through a height of 100 cm. When brought in contact with a flame, it deflagrated, but when pressed into a detonator capsule, it was not ignited by the spit of a fuze. A charge of 0.4 gram pressed into a detonator capsule was detonated by 0.2 gram of mercury fulminate, confined by a reinforcing cap, and crushed an average of 29 grams of sand in the sand test bomb as compared with 30 grams for the same weight of TNT.

SUMMARY

The silver salts considered in this article are not efficient detonating materials and so cannot compete with the detonating compounds in general use—that is, especially mercury fulminate.

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E. P. BUXTON,
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U. S. Bureau of Mines.

12. Berthelot, M.P.E., Explosives and their power. Hake and Macnab, 1892, pp. 366, 475.
13. Wohler, F., Annalen der Chemie, vol. 30, 1839, p. 4.
14. Hoitsema, F., Z. Phys. Ch., vol. 21, 1896, p. 142.
15. Hantzsch, A., and St. Opolski, Silver salt of hexanitrodiphenylamine, Berichte, vol. 41, 1908, p. 1747.

Personnel

Edited by Major John A. Brooks, Jr., Military Personnel Section, Office of the Chief of Ordnance

Commendations for Heroic Conduct

FOR heroic conduct during a fire and explosion at Picatinny Arsenal, May 28, 1925, commendations have been issued by the War Department to Major N. F. Ramsey, Ord. Dept., U. S. A., Commanding Officer, Maj. F. H. Miles, Jr., Ord. Dept., U. S. A., and Messrs. Thomas E. James, Thomas M. Roach, John Stank, William C. Swayze and Charles Zeek.

The commendations, as published, follow:

WAR DEPARTMENT,
Washington, Feb. 11, 1926.
GENERAL ORDERS
No. 1

* * * *

"VI. COMMENDATIONS FOR HEROIC CONDUCT.—The following-named officers and enlisted men are commended for heroic conduct, but such conduct, not having occurred in action, is not within the provisions of law authorizing decorations:

* * * *

"*Francis H. Miles, jr.*, major, Ordnance Department, United States Army. For heroic conduct at Picatinny Arsenal, Dover, New Jersey, May 28, 1925. Major *Miles*, with utter disregard for personal safety, entered a burning building containing loaded bombs and explosives, and assisted in removing an injured civilian employee. Immediately after the rescue the building was completely demolished by the detonation of burning explosives. Major *Miles'* conduct at this time is deserving of commendation and reflects credit upon himself and the Army of which he is a member. Address: Care of The Adjutant General, Washington, D. C. Entered Military Academy from Massachusetts.

"*Norman F. Ramsey*, major, Ordnance Department, United States Army. For heroic conduct at Picatinny Arsenal, Dover, New Jersey, May 28, 1925. Major *Ramsey*, with utter disregard for personal safety, entered a burning building containing loaded bombs and explosives, directed and assisted in the removing of an injured civilian employee. Immediately after the rescue the building was completely demolished by detonation of burning explosives. Major *Ramsey's* conduct at this time is deserving of commendation and reflects great credit upon himself and the Army of which he is a member. Address: Care of The Adjutant General, Washington, D. C. Entered Military Academy from Kansas."

Cited for Bravery

Left to right, top row: Maj. F. H. Miles, Jr., Ord. Dept., U. S. A., Maj. N. F. Ramsey, Ord. Dept., U. S. A., and Thomas M. Roach. Middle row: Thomas E. James and John Stank. Bottom row: William C. Swayze and Charles Zeek.

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"OFFICE OF THE CHIEF OF ORDNANCE,
Washington, D. C.,
Dec. 23, 1925.
GENERAL ORDERS
No. 2

The following named civilian employees are commended for heroic conduct, beyond the call of duty, upon the occasion stated, namely:

John Stank, Assistant Foreman (Experimental Loading), Picatinny Arsenal, Dover, New Jersey. For heroism at the Picatinny Arsenal, May 28, 1925. Mr. Stank, at the risk of his life, entered an explosive loading building damaged and set on fire by the explosion of a melting kettle and removed loaded bombs until the heat of the flames made it impossible for him to remain. He then assisted in the removal of the body of an explosive operator killed by the explosion of the kettle. Immediately after the rescue party had removed the body, and before the party were clear of the danger zone, the building was completely demolished by the detonation of burning explosives. Residence: Wharton, New Jersey.

Charles Zeek, Assistant Foreman (Primer Loading), Picatinny Arsenal, Dover, New Jersey. For heroism at the Picatinny Arsenal, May 28, 1925. Mr. Zeek at the risk of his life, assisted in the removal of bombs from the im-

mediate vicinity of a burning explosive loading building containing loaded bombs and remained on duty in the danger zone until the building was completely demolished by the detonation of burning explosives. Residence: Oak Ridge, New Jersey.

Thomas E. James, Foreman (millright), Picatinny Arsenal, Dover, New Jersey. For heroism at the Picatinny Arsenal, May 28, 1925. Mr. James, at the risk of his life, assisted in the removal of the body of an explosive operator from the vicinity of a burning explosive loading building containing loaded bombs. Immediately after the rescue party had removed the body, and before the party were clear of the danger zone, the building was completely demolished by the detonation of burning explosives. Residence: Wharton, New Jersey.

William C. Swayze, Chauffeur, Picatinny Arsenal, Dover, New Jersey. For heroism at the Picatinny Arsenal, May 28, 1925. Mr. Swayze, at the risk of his life, assisted in the removal of the body of an explosive operator from a burning explosive loading building containing loaded bombs. Immediately after the rescue party had removed the body, and before the party were clear of the danger zone, the building was completely demolished by the detonation of burning explosives. Residence: Dover, New Jersey.

Thomas M. Roach, Chauffeur, Picatinny Arsenal, Dover, New Jersey. For heroism at the Picatinny Arsenal, May 28, 1925. Mr. Roach, at the risk of his life, assisted in the removal of the body of an explosive operator from a burning explosive loading building containing loaded bombs. Immediately after the rescue party had removed the body, and before the party were clear of the danger zone, the building was completely demolished by the detonation of burning explosives. Residence: Dover, New Jersey.

A copy of this order will be placed on the record of each of the employees above cited.

C. C. WILLIAMS,
Major General, Chief of Ordnance.

Meeting of Boston Post, A. O. A.

THE second annual meeting of the Boston Post, Army Ordnance Association, was held at the Harvard Club of Boston on the evening of May 27, 1926. The business meeting was called to order promptly at 7:00 P. M.

Officers were elected for the coming year as follows: President, Col. Edward F. Miller, Ord. Res.; Vice-President, Alvan T. Simonds; Directors (to serve two years), G. L. Gilmore, Everett Morss and Maj. R. F. Whitelegg, Ord. Res.

Col. Charles H. Tenney, Ord. Res., was elected to represent the Boston Post on the Board of Directors of the Army Ordnance Association.

At the conclusion of the business meeting dinner was served.

The meeting was addressed by Brig. Gen. C. L'H. Ruggles, Ord. Dept., U. S. A., Assistant Chief of Ordnance, who spoke of the work being done by the Army Ordnance Association in assisting the Ordnance Department in its preparations for the National Defense.

Following General Ruggles, Col. Tracy C. Dickson, Ord. Dept., U. S. A., the Commanding Officer of Watertown Arsenal, spoke in a very interesting manner of the experimental and development work that has been done and is still in progress at Watertown. Col. Dickson gave especial credit to the capable and energeic officers and civilian employees at the Arsenal who have conducted these investigations and experiments under his direction.

Sixty members and guests were present and all seemed much interested in the speakers. A group of twenty reserve officers who were taking a course of instruction at Watertown Arsenal attended in a body.

A trophy was provided for by those present to be competed for at the shoot at the Wakefield Rifle Range, sponsored by the United Services of New England. This is to be known as the Army Ordnance Trophy.

New York Post, A. O. A., Elects Officers

AT THE annual meeting and dinner of the New York Post, Army Ordnance Association, held at the Army and Navy Club, New York City, Thursday, April 15, 1926, the following officers were elected: President, Gen. Guy E. Tripp. Vice-Presidents—Col. T. L. Ames, Ord. Dept., U. S. A.; Col. J. L. Walsh, Ord. Res.; Lt. Col. H. B. Machen, Ord. Res.; Lt. Col. R. D. Coombs, Ord. Res. Secretary, Capt. H. W. Churchill, Ord. Dept., U. S. A.; Treasurer, Capt. C. H. Keck, Ord. Dept., U. S. A.

Executive Committee—Gen. Guy E. Tripp, Chairman; James A. Farrell, Col. T. L. Ames, Ord. Dept., U. S. A.; Col. J. L. Walsh, Ord. Res.; Col. C. E. Warren, C A. Res.; Lt. Col. H. B. Machen, Ord. Res.; Lt. Col. R. D. Coombs, Ord. Res.; Lt. Col. E. L. Sherwood, Ord. Res.; Maj. Earl McFarland, Ord. Dept., U. S. A.; Maj. C. E. Davies, Ord. Res.; Maj. J. M. Boyle, Ord. Res.; Capt. C. H. Keck, Ord. Dept., U. S. A.; Capt. H. W. Churchill, Ord. Dept., U. S. A.

Meeting of Ordnance Reserve Officers Assigned to Buffalo District and Watervliet Arsenal

A JOINT meeting of all officers assigned to the Buffalo Ordnance District and to Watervliet Arsenal, was held at 8:00 P. M. on May 21st in the Assembly Hall, Main Office, Watervliet Arsenal. All officers in Troy, Albany, Watervliet, and Schenectady (Regular, Reserve and National Guard) were invited to attend. Col. E. D. Bricker, Ord. Dept., U. S. A., Commanding Officer at Watervliet, also extended an invitation to all officers to inspect the shops during the afternoon, and approximately thirty officers, in addition to the five now undergoing training at the Arsenal, availed themselves of this opportunity and were conducted through the shops in small groups by the officers on duty at the Arsenal. Eighty-one officers attended the meeting in the evening, and because of the interest and enthusiasm shown, plans are being made to hold several similar joint meetings during next winter.

The meeting was opened with an address by Colonel Bricker. This was followed by an illustrated lecture, "Experimental and Development Work of the Ordnance Department," by Maj. G. M. Barnes, Office of the Chief of

Ordnance. In behalf of the Reserve Officers of Albany a gold wrist watch was presented to Colonel F. S. Bowen, in charge of Reserve activities in Albany.

After motion pictures and refreshments, the meeting was given over to a general discussion and inspection of war plans of both Watervliet Arsenal and the Buffalo Ordnance District.

Reserve Officers Entertain

IN COMPLIMENT to the officers and ladies of the Post at Raritan Arsenal, Metuchen, N. J., the Ordnance Field Service Reserve Officers of the New York Metropolitan area and the Middlesex County Reserve Officers' Association of New Jersey entertained at a dance at the Metuchen Club, Metuchen, N. J., on Saturday, May 22, 1926.

The party was a very delightful one, and was attended by many prominent local people, including officers from the R. O. T. C. at Rutgers University, New Brunswick, N. J., and also officers from the 78th Division Headquarters at Newark, N. J.

The committee in charge of the dance were Lt. Col. E. L. Sherwood, Ord. Res.; Maj. J. Kingsley Powell, Inf. Res.; and Capt. Jacob M. Klein, Q. M. Res.

Cleveland Ordnance Reserve Officers Visit Erie Proving Ground

ON May 1st and 2nd, Ordnance Reserve Officers of Cleveland and vicinity made a trip of inspection to Erie Proving Ground, LeCarne, Ohio, for purpose of instruction and inspection. This visit was a part of the winter course of informal talks and lectures that have been conducted in Cleveland.

Through the courtesy of Capt. J. E. Brown, Ord. Dept., U. S. A., Commanding Officer, the Proving Ground was turned over to the Reserve Officers for that time with full course of instruction and instructors.

Those officers who arrived early Saturday afternoon spent the afternoon at pistol practice, under the instruction of Lieut. Orcutt, Ord. Dept., U. S. A., in Command of the 84th Ordnance Company. While this was entirely informal some very good scores were turned in.

The evening was spent under the instruction of Captain John Johnson, Ord. Res., who discussed depot records, property accounting, property records, the Ordnance provision system and similar office work. His explanations and instruction were complete and very interesting. They were examplified by examination of the depot records.

Sunday was spent in detailed inspection of the warehouses, and a study of warehouse system, methods of grouping, storing and maintaining material in storage. The periodical inspection, cleaning and preserving of the material was gone into.

Detailed instruction regarding the following items of equipment was given by Lt. H. H. Needham, Ord. Res., Shop Superintendent, Erie Proving Ground: 75-mm. Field Gun, Model 1897, 155-mm. Howitzer, 155-mm. Guns, 240-mm. Howitzer, equipment of light and heavy maintenance companies.

During their stay, the Reserve Officers were quartered in the Officers' Club and messed with the 84th Ordnance Company. Every effort possible was made by the Commanding Officer to make the stay profitable as well as enjoyable.

The following Reserve Officers were present: Maj. J. A. Haworth, Rossford, Ohio; Capt. A. W. Heinrich, Cleveland, Ohio; Capt. John Johnson, Erie Proving Ground; Capt. K. L. Pohlman, Cleveland, Ohio; 1st Lt. R. H. Coburn, Cleveland, Ohio; 1st Lt. J. H. Christman, Cleveland, Ohio; 1st Lt. H. E. Mann, Cleveland, Ohio; 1st Lt. K. C. Schoepfle, Cleveland, Ohio; 1st Lt. J. B. Hoon, Cleveland, Ohio; 1st Lt. H. H. Needham, Erie Proving Ground; 2nd Lt. F. T. Francis, Cleveland, Ohio; 2nd Lt. V. Savage, Cleveland, Ohio; 2nd Lt. C. A. Hudson, Fremont, Ohio.

The visit was aranged by Maj. C. B. Thummel, Ord. Dept., U. S. A., on duty with the Organized Reserves, Cleveland, Ohio, and Lieut. C. E. Whitney, Ord. Dept., U. S. A., Executive Officer, Cleveland District Ordnance Office.

Ordnance Reserve Officers Visit Erie Proving Ground

Standing, left to right: Lt. J. B. Hoon, Capt. A. W. Heinrich, Lt. V. B. Savage, Lt. K. C. Schoepfle, Lt. C. E. Whitney, Lt. H. E. Mann, Lt. J. H. Christman, Capt. E. A. Robbins, Lt. C. A. Hudson, Maj. J. E. Haworth. Kneeling, left to right: Lt. J. W. Orcutt, Capt. K. L. Pohlman, Capt. J. E. Brown, Maj. C. B. Thummel, Lt. F. T. Francis, Lt. R. H. Coburn.

Recently Reappointed Ordnance Reserve Officers

THE following reserve officers have accepted reappointment in the Ordnance Department Reserve:

Lt. Col. Winthrop Sargent, Jr., Ord. Res.,
Haverford, Pa.

Maj. Thomas M. Chance, Ord. Res.,
843 Drexel Bldg., Philadelphia, Pa.

Maj. Lewis C. Dysart, Ord. Res.,
Columbus Gen. Res. Depot, Columbus, O.

Maj. Charles E. Fiske, Ord. Res.,
20 Fort Greene Place, Brooklyn, N. Y.

Maj. Parke A. Galleher, Ord. Res.,
1608 Hobart St., N. W., Washington, D. C.
Maj. John C. Gray, Ord. Res.,
1739 Eye St., N. W., Washington, D. C.
Maj. Richard W. B. Happer, Ord. Res.,
Hq. 5th Corps Area, Ft. Hayes, Columbus, O.
Maj. Allen C. Harris, Ord. Res.,
34 Plumwood Road, Dayton, Ohio.
Maj. Elmer Kemp, Ord. Res.,
Augusta Arsenal, Augusta, Ga.
Maj. George L. King, Ord. Res.,
Benicia Arsenal, Benicia, Calif.
Maj. Edward Reiter, Ord. Res.,
Hqrs. Panama Canal Dept., Quarry Heights, C. Z.
Maj. William J. Rusch, Ord. Res.,
Schenectady Gen. Res. Depot, Schenectady, N. Y.
Maj. Fred Togerson, Ord. Res.,
Philippine Dept., Manila, P. I.
Maj. Bernard Whittaker, Ord. Res.,
Worcester, Pa.
Capt. Joseph P. Bell, Ord. Res.,
230 No. Monroe St., Media, Pa.
Capt. Arthur Brest, Ord. Res.,
2925 Buchanan St., San Francisco, Cal.
Capt. Hugh Carmack, Ord. Res.,
404 Barret Place, San Antonio, Tex.
Capt. Harry D. Carter, Ord. Res.,
Box 529, Chapel Hill, N. C.
Capt. Alexander H. Cockburn, Ord. Res.,
Aberdeen Proving Ground, Md.
Capt. Harold A. Fasick, Ord. Res.,
85 Fenno St., Wollaston, Mass.
Capt. Richard H. Franchot, Ord. Res.,
Grand Rapids Saving Bank, Grand Rapids, Mich.
Capt. John W. Francis, Ord. Res.,
Springfield Armory, Mass.
Capt. John Gardner, Ord. Res.,
Hqrs. 3rd Corps Area, Baltimore, Md.
Capt. John Gebelin, Ord. Res.,
Little Rock Air Intermediate Depot, Little Rock, Ark.
Capt. Harry B. Johnson, Ord. Res.,
387 Main St., Springfield, Mass.
Capt. James A. Landers, Ord. Res.,
P. O. Box 112, Talihina, Okla.
Capt. Joseph H. Lewis, Ord. Res.,
Route No. 3, Montrose, Colo.
Capt. Clarence McClure, Ord. Res.,
Raritan Arsenal, Metuchen, N. J.
Capt. John W. Peairs, Ord. Res.,
1521 Mazant St., New Orleans, La.
Capt. John F. Ordway, Ord. Res.,
12 Grace Court, Brooklyn, N. Y.
Capt. John W. Quickmire, Ord. Res.,
Curtis Bay Ord. Res. Depot, Curtis Bay, Md.
Capt. Albert A. Riedinger, Ord. Res.,
1125 Highland Ave., Houston, Tex.
Capt. Edward F. Trainor, Ord. Res.,
16 Fernald Terrace, Dorchester, Mass.
Capt. Arthur Whitcraft, Ord. Res.,
341 Southern Ave., Bucyrus, Ohio.
1st Lt. Horace H. Crow, Ord. Res.,
451 Ea. 3rd St., Los Angeles, Cal.
1st Lt. Herbert K. Cummings, Ord. Res.,
4213 Ellicott St., N. W., Washington, D. C.
1st Lt. William H. Darrow, Ord. Res.,
49 Front St., Owego, N. Y.
1st Lt. Paul W. Gerdes, Ord. Res.,
120 Sylvan Terrace, Harrisburg, Pa.
1st Lt. John O. Hayes, Ord. Res.,
Panama Ord. Depot, Corozal, C. Z.
1st Lt. George Hilsinger, Ord. Res.,
Fort Worden, Wash.
1st Lt. Louis J. Knight, Ord. Res.,
36 Rolfe St., Auburn, R. I.
1st Lt. Ernest C. Moriarty, Ord. Res.,
3661 13th St., N. W., Washington, D. C.
1st Lt. Robert E. Pate, Ord. Res.,
c/o 102 Regiment Engr. Armory, 216 Fort Washington Ave., New York, N. Y.
1st Lt. John W. Raher, Ord. Res.,
Gen. Del. Clallam Bay, Wash.
2nd Lt. Roy L. Brown, Ord. Res.,
121 So. Meridian St., Indianapolis, Ind.

Recently Commissioned Ordnance Reserve Officers

THE following have accepted reserve commissions since last issue of ARMY ORDNANCE:

Maj. Edwin M. Hadley, Ord. Res.,
4750 Woodlawn Ave., Chicago, Ill.
Maj. Walter Mangum, Ord. Res.,
c/o Remington Arms Co., 25 Broadway, New York, N. Y.
Maj. Samuel Powell, Ord. Res.,
524 Oregon Bldg., Portland, Ore.
Capt. Joseph A. Denn, Ord. Res.,
231 No. Main St., Rosebury, Ore.
Capt. Samuel J. Shoglow, Ord. Res.,
Fort McPherson, Ga.
Capt. Howard R. Williams, Ord. Res.,
18 Priscilla Apt., 3425 Michigan Ave., Cincinnati, O.
1st Lt. Edward Bergman, Ord. Res.,
Ord. Dept. Hq. 4th Corps Area, Atlanta, Ga.
1st Lt. Elmer E. Erickson, Ord. Res.,
1186 208 So. LaSalle St., Chicago, Ill.
1st Lt. Boynton M. Green, Ord. Res.,
P. O. Box 1371, Stanford Univ., Calif.
1st Lt. Harry Parker, Ord. Res.,
168 Bunker Ave., Meriden, Conn.
1st Lt. Joseph Proske, Ord. Res.,
1112 35th St., Rock Island, Ill.
1st Lt. Arthur J. Zschokke, Ord. Res.,
526 Forest Ave., Palo Alto, Cal.
2nd Lt. Everett R. Armstrong, Ord. Res.,
1517 East 15th St., Brooklyn, N. Y.
2nd Lt. Roy K. Beaudry, Ord. Res.,
28 Vellevue Ave., Adams, Mass.
2nd Lt. John R. Kimberly, Ord. Res.,
408 E. Wisconsin Ave., Neenah, Wisc.
2nd Lt. Oscar A. Muenz, Ord. Res.,
935 Fulton Rd. N. W., Canton, Ohio.
2nd Lt. Philip A. Salmon, Ord. Res.,
809 Rahway Ave., Elizabeth, N. J.

The following named officers have recently transferred from other branches and accepted commissions in the Ordnance Reserve Corps:

Capt. Ralph E. Whittle, Ord. Res.,
65 Meredith St., Springfield, Mass.

2nd Lt. Francis A. Hennigan, Ord. Res.,
1302 Fayette St., N. S., Pittsburgh, Pa.

2nd Lt. Thomas D. Radcliffe, Ord. Res.,
2111 34th Ave., Oakland, Cal.

2nd Lt. Vernon Reid, Ord. Res.,
Box 294, Forsyth, Ga.

2nd Lt. Isidor Straus, 2nd, Ord. Res.,
c/o R. H. Macy & Co., Herald Square, New York, N. Y.

Recently Assigned Ordnance Reserve Officers

THE following reserve officers have recently been assigned as indicated after their names:

Maj. Edwin M. Hadley, Ord. Res., Manufacturing Service, Chicago District Ordnance Office, Chicago, Ill.

Maj. Samuel Powell, Ord. Res., Manufacturing Service, San Francisco District Ordnance Office, San Francisco, Calif.

Capt. Joseph A. Denn, Ord. Res., Manufacturing Service, San Francisco District Ordnance Office, San Francisco, Calif.

Capt. Samuel J. Shoglow, Ord. Res., Territorial Assignment Group.

Capt. Edward A. Wagner, Ord. Res., Manufacturing Service, Chicago District Ordnance Office, Chicago, Ill.

1st Lt. Edward Bergman, Ord. Res., Territorial Assignment Group.

1st Lt. John L. Christie, Ord. Res., Manufacturing Service, Bridgeport District Ordnance Office, Springfield Armory, Springfield, Mass.

1st. Lt. Elmer E. Erickson, Ord. Res., Manufacturing Service, Chicago District Ordnance Office, Chicago, Ill.

1st Lt. Boynton M. Green, Ord. Res., Manufacturing Service, San Francisco District Ordnance Office, San Francisco, Calif.

1st Lt. John H. Johnson, Ord. Res., Manufacturing Service, New York District Ordnance Office, New York, N.Y.

1st Lt. Arthur H. Nordstrom, Ord. Res., Administration Division, Contract & Advisory Section, Washington, D.C.

1st Lt. Joseph Proske, Ord. Res., Manufacturing Service, Rock Island Arsenal, Rock Island, Ill.

2nd Lt. Everett R. Armstrong, Ord. Res., Manufacturing Service, New York District Ordnance Office, New York, N.Y.

2nd Lt. Roy K. Beaudry, Ord. Res., Manufacturing Service, Bridgeport District Ordnance Office, Springfield Armory, Springfield, Mass.

2nd Lt. Ernest Gaskins, Ord. Res., Manufacturing Service, Birmingham District Ordnance Office, Birmingham, Ala.

2nd Lt. Howard H. Josephs, Ord. Res., Manufacturing Service, San Francisco District Ordnance Office, San Francisco, Calif.

2nd Lt. John R. Kimberly, Ord. Res., Manufacturing Service, Chicago District Ordnance Office, Chicago, Ill.

2nd Lt. Thomas D. Radcliffe, Ord. Res., Manufacturing Service, San Francisco District Ordnance Office, San Francisco, Calif.

2nd Lt. Vernon Reid, Ord. Res., Territorial Assignment Group.

2nd Lt. Isidor Straus, 2nd, Ord. Res., Manufacturing Service, New York District Ordnance Office, New York, N.Y.

National Guardsmen at Citizens' Military Training Camps

INASMUCH as one of the principal objects of the Citizens' Military Training Camps is the training given therein in the essentials that will aid a young man to undertake the work to fit himself for a commission either in the National Guard or in the Reserves, the opportunity for commanders of National Guard organizations to send to these camps prospective officer material is of high importance.

All instruction at these camps is based on the sound foundation of good citizenship and the rights, duties and privileges of American youths. A second important feature is the building up of the body of the trainees by means of carefully planned athletic exercises together with studiously regulated periods of military instruction. Another important phase of training is found in the discipline and routine of the camps.

It is apparent to every officer, whether he be Guardsman, Reserve or Regular, that the product of these camps will be valuable to any organization, but especially will they be valuable additions to our citizen-soldier-units.

California has made great progress with its citizen-soldiery in the last few years, and the interest shown by the State in the Citizens' Military Training Camps is evidenced by the enrollment therein and especially by the large percentage of trainees that return from year to year to the camps. In 1925, California led the country in percentage of trainees who were steadfastly pursuing the yearly courses with the object of attaining a certificate of proficiency at the end of the Blue Course.

Not the least welcome among our young men are those National Guardsmen whom we have had with us at every camp. Their previous training in the ranks of the Guard was always found to be basically sound and their spirit fine in quality, and in most cases, undoubted evidences of progress in leadership were apparent.

This State will have three training camps during this coming summer. The Del Monte camp will give training in infantry, cavalry and field artillery to 950 candidates. Coast Artillery camps will be at Fort Winfield Scott, Presidio of San Francisco, and Fort MacArthur, San Pedro. Fort Scott will accept 170 and MacArthur will train 80. All three camps open on June 27 and continue for 30 days. All these camps are free of expense, and this includes amusements and even laundry. Mileage at 5c to and from camps is paid to the trainees, and that sum is ample for all travel expenses.

In previous years, a number of instructors in these camps have been chosen from the National Guard of the State, and in every case, the ability of these officers as instructors and leaders has been most marked. Then, too, these instructors have been most valuable in building up the one-army spirit, and that in itself proved highly valuable for the future of the Guard.

Applications on the part of Guardsmen to enroll in the camps of their selection should be forwarded through military channels to the Headquarters of the 9th Corps Area. It is all important that careful selection as to high character be exercised in making recommendations for acceptance at the camps. It is quality, not quantity, in the trainees that is desired. The best material in the community or in the company is alone acceptable.

Col. E. V. Smith, *Inf., U. S. A.*

Ordnance News in Pictures

Secretary of War Takes a Ride in an Ordnance Cross-Country Car.

Hon. Dwight F. Davis, Secretary of War, "enjoyed" a ride in a cross-country car during a demonstration of these vehicles held in Washington, D. C., May 24, 1926. In the car, shown nosing into a ditch near the Potomac River, are (front seat), Secretary Davis and Maj. A. B. Quinton, Jr., Ord. Dept., U. S. A., (rear seat) Maj. Gen. John L. Hines, U. S. A., Chief of Staff (left) and Maj. Gen. C. C. Williams, U. S. A., Chief of Ordnance (right).

(Underwood and Underwood)

(International Newsreel)

14-Inch Railway Gun Tested at Fort MacArthur, Cal.

After a successful trans-continental journey from Aberdeen Proving Ground, Md., to the Pacific Coast, this giant weapon is now at Fort MacArthur, where it is shown being maneuvered from its railway mount to a concrete emplacement.

Recipient of Ordnance Honors at Naval Academy.

Midshipman Clifford H. Duerfeldt, Class of '26, U. S. Naval Academy, receiving a cup from Hon. Curtis D. Wilbur, Secretary of the Navy, for proficiency in practical ordnance and gunnery during the past year.

(International Newsreel)

Who's Who in This Issue

MAJ. N. F. RAMSEY, Ord. Dept., U. S. A., is Commanding Officer, Picatinny Arsenal. During the greater part of the World War Major Ramsey was stationed at Rock Island Arsenal where, for a time, he was in charge of manufacturing operations. He served in France from October, 1918, to August, 1920, on duty in the Office of the Chief Ordnance Officer, A. E. F., as Chief of the Supply Division; with the Chief Ordnance Officer, American Forces in France; and as liaison officer with Direction d'Artillerie. He is a graduate of the Army War College, class 1921, and was on duty in the Office of the Assistant Secretary of War 1921-1922.

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MAJ. F. H. MILES, Jr., Ord. Dept., U. S. A., is Chief of Operations, Picatinny Arsenal. During the World War Major Miles was chief inspector of powder and explosives, Inspection Division, Office of the Chief of Ordnance. He served in the liaison office, Inspection Division, A. E. F. Later he served as Commanding Officer at Amatol and Tullytown Arsenals, Commanding Officer at Picatinny Arsenal and Ordnance Officer at Fort Sill, Okla.

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DR. G. C. HALE, Chief Chemist at Picatinny Arsenal, has been connected with the research organization of that establishment since its inauguration during the World War. In 1920 he was sent to Germany on a special mission to make a study of foreign ammunition and explosives where he was stationed with the Ordnance Officer at Coblenz.

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MAJ. H. H. Zornig, Ord. Dept., U. S. A., Chief of the Technical Division, Picatinny Arsenal, is director of technical research and development at that establishment. During and immediately after the World War he was stationed at Watertown Arsenal where he was at various times superintendent of the foundry, forge and other hot metal shops. He served as Ordnance Officer, First Corps Area, 1921-1922, and received the degree of M. S. from the Massachusetts Institute of Technology, 1923.

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CAPT. IRA A. CRUMP, Ord. Dept., U. S. A., engineering staff, Technical Division, Picatinny Arsenal, is in charge of pyrotechnic and grenade development. During the World War Captain Crump was, for a time, in command of an antiaircraft battalion, A. E. F.

MR. H. M. BRAYTON, Assistant to the Director of Technical Activities, Picatinny Arsenal, is coordinator of the mechanical engineering features of bombs, artillery ammunition, grenades and pyrotechnics. A captain in the Ordnance Department during the World War, he served at Frankford Arsenal and later as Chief Research Engineer on artillery ammunition at that establishment.

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MR. H. S. DECK, Chief of the Plant Engineering Division, Picatinny Arsenal, was formerly Chief Engineer for the Laflin and Rand Powder Company. During the World War he served on the staff of the Explosives Section, Production Division, Office of the Chief of Ordnance. Author of the Ordnance Safety Manual, he is now in charge of war plans for artillery ammunition and loading plants at Picatinny.

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CAPT. J. P. HARRIS, Ord. Dept., U. S. A., Chief of the Planning Division and of the Loading Department at Picatinny Arsenal, served during the World War in the Explosives Section, Engineering Bureau, Office of the Chief of Ordnance. Later he was Commanding Officer at Tullytown Arsenal, Pa., following which he assisted in the planning of Picatinny as an ammunition arsenal. He served at San Antonio Arsenal, 1922, and was Ordnance Supply Officer, Eighth Corps Area, 1923.

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MR. C. J. BAIN is in charge of the development of high explosives and loading, Technical Department, Picatinny Arsenal. Before and during the World War he was Research Chemist in high explosives with the E. I. duPont de Nemours & Company and later served with the Ammunition Supply Division, Field Service, Office of the Chief of Ordnance.

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MR. FRED OLSEN, Assistant to the Director of Technical Activities, Picatinny Arsenal, was formerly in charge of chemical research, Aetna Explosives Company. Later he served on the staff of the Explosives Section, Ammunition Division, Office of the Chief of Ordnance. He is now coordinator of chemical research and development work on smokeless powder, high explosives and loading at Picatinny Arsenal.

Patents

Patent Rights of Government Employees

W. N. Roach

SINCE entering the Patent Branch, Ordnance Department, I have been repeatedly asked about the rights of a government employee in his invention, and have heard so many statements of his rights which appear to me to have no justification in law, that I decided to jot down a few of my thoughts on the subject in the hope that they may have some tendency to clear up this unnecessarily confused question.

First, it would be well to determine what a patent is; what rights it confers upon the patentee; and who is entitled to have such rights conferred upon him, that is, receive a patent.

For our purposes, there is no need to trace the history of patent monopolies beyond the adoption of the Constitution. In the Constitution of the United States, among the powers granted to Congress, we find, Art. 4, Sec. 8.

> "* * * * To promote the Progress of Science and useful Arts, by securing for limited Times to Authors and Inventors the exclusive right to their respective Writings and Discoveries."

In exercise of the authority vested in it by the Constitution, Congress has, from time to time, enacted laws which form the basis of our present patent system. Of these laws, the following are of interest to the present discussion:

Rev. Stat. Sec. 4884: "Every patent shall contain * * * * a grant, to the patentee, his heirs or assigns, for the term of seventeen years, of the exclusive right to make, use and vend the invention or discovery throughout the United States and the Territories thereof."

Sec. 4886: "Any person who has invented * * * * any new and useful art, machine, manufacture, or composition of matter * * * * may, upon payment of the fees required by law, and other due proceedings had, obtain a patent therefor."

Other sections, which need not be quoted here, provide what a patent application is to contain, and one of these requirements is, a description of the invention, sufficiently full, clear, and exact to enable others skilled in the art to which the invention appertains, to practice the invention.

From the foregoing it is quite clear that our patent system contemplates a disclosure to the public of the invention, to the end that the same may not be lost to posterity, and, in return for such disclosure, gives the inventor certain exclusive rights for a limited time (17 years).

Clearly the inventor receives from a patent, nothing that he did not already possess, other than the right to exclude others from making, using and vending his invention during the life of the patent.

There are present here all the elements of a contract; the necessary parties, namely, the public on the one hand and the inventor on the other; a sufficient consideration, namely, disclosure of the invention in return for sole right to enjoyment of the invention for a limited time. Moreover the courts have held that a patent is in the nature of a contract between the inventor and the public. (See 285 Fed. 840; 106 Fed. 693.)

Congress has provided, as we saw from Rev. Stat. Sec. 4886—that this contract may be entered into with *any person*—since officers and employees of the government are undoubtedly included within the term "any person" it seems evident that they are entitled to apply for and receive letters patent in the absence of any special prohibitive legislation, and no such legislation can be found.

In Solomons vs. United States, 137 U. S. 342—we find that the Supreme Court of the United States says:

> "The Government has no more right to appropriate a man's property invested in a patent than it has to take his property vested in real estate; nor does the fact that the inventor is at the time of his invention in the employ of the government transfer to it any title or interest therein. There is no difference between the government and any other employer in this respect."

Having now established the character of a patent; the right of a government employe to receive a patent; and the rights granted by a patent; it would seem logical to inquire in what manner these rights may be disposed of to the end that we may determine with some degree of certainty when an employe has parted with any of his rights to his employer.

An assignment is an instrument conveying the greatest rights that may be conveyed under a patent. A transfer of the whole right, title and interest in and to a patent; or a transfer of an undivided portion of such whole right, title and interest; or a transfer of the exclusive rights under a patent within a specified territory, amounts to an assignment. Anything less than these is a mere license.

Licenses may be broadly licenses, as granting the right (non-exclusive) to make, use and sell the invention covered by the patent, throughout the United States and its Territories, or throughout a specified portion thereof; or

the license may be of a more limited character, sometimes called a shop right, as, where a patentee grants the right to make and use the invention (usually a machine) in a specified factory or shop.

Any of these rights may be granted by instrument in writing, and licenses may be granted orally, or they may be granted by implication, that is, the relationship and acts of the parties may be such that a license will be implied. It follows that, since these rights may be conveyed, agreements to convey may also be entered into, but, in the case of an agreement to convey an interest amounting to an assignment, especially a complete assignment, the agreement must be clear and unequivocal and should leave no doubt as to the intent of the parties thereto.

In the case of an implied license, the acts of the inventor must have been such as to estop him from denying the right of the other party (usually his employer) to use the invention.

It would now be of advantage to examine a few of the leading cases which have been decided by the courts to see when and in what manner these rights are lost to the inventor (employee) and secured by the employer.

First let us consider a case in which the employer (the United States) gained no rights in the invention of an employe (an army officer).

In this case (U. S. vs. Burns, 12 Wall. 246), Sibley, an army officer, invented a tent on which he secured a patent. The tent was adopted for use by the Army. A contract was entered into between Sibley and the United States Government by the terms of which Sibley was to receive $5.00 for every tent made by the government. Sibley assigned a one-half interest in his contract to Burns, another army officer. Payments under the contract were duly made until Sibley resigned his commission to enter the service of the Southern Confederacy, after which Burns' share of the payments was continued. Finally the Secretary of War ordered these payments stopped, and Burns brought suit in the Court of Claims. His claim was allowed and an appeal was taken to the Supreme Court of the United States. Justice Field, in delivering the opinion of the court, said:

> "If an officer in the military service, not especially employed to make experiments with a view to suggest improvements, devises a new and valuable improvement in arms, tents or any other kind of war material, he is entitled to the benefit of it, and to letters patent for the improvement from the United States, equally with any other citizen not engaged in such service; and the Government cannot, after the patent is issued, make use of the improvement any more than a private individual without license of the inventor or making compensation to him."

From this case, which is still good law, it is readily seen that the mere fact that one is in the employment of the Government does not deprive him of the right to his inventions and to secure letters patent thereon.

The following cases are ones in which a license was implied:

City of Boston vs. Allen (91 Fed. 248).

Doten was employed by the city of Boston as an engineer to supervise construction in rebuilding a ferry. Doten during such employment made certain improvements in construction on which he afterwards secured a patent.

Later the city rebuilt another ferry and used the patented improvements. Doten then made claim for compensation but was not paid. Sometime thereafter Allen, to whom Doten had assigned, sued for damages for infringement of the patent.

The court held that for the first use no recovery could be had, but, since the later use has been persisted in despite the inventor's objection, recovery therefor could be had.

In the case just quoted it is evident that Doten, by placing his improvements in the ferry constructed under his supervision, must have intended the city to enjoy the benefit of such improvements in so far as that particular ferry was concerned. In other words, the facts were such as to imply a shop right extending to that particular ferry.

In McClurg vs. Kingsland (Howard, 202), Harley was employed by Kingsland *et al* and while receiving wages from them made an invention after conducting experiments in their foundry and wholly at their expense. Because of the benefits of the invention his wages were increased. The invention was used by the defendants for about a year without objection on Harley's part. Harley then had a misunderstanding with his employers and left their employ and then assigned his patent to McClurg. After making the assignment he notified Kingsland *et al* that they should stop using his invention. The court held that the facts were sufficient to justify the presumption of a license to use the investion.

In the case of Solomons vs. United States (137 U. S. 342), Clark, Chief of the Bureau of Engraving and Printing, was called into consultation by a sub-committee of the Committee on Ways and Means, having charge of devising a new revenue stamp, and was assigned the duty of devising a stamp, with the understanding that the best stamp that Clark could devise would be adopted. Clark devised a stamp, and plates for printing the stamp were engraved at the Bureau of Engraving and Printing and specimen stamps printed on the machines at the Bureau. Before final adoption of the stamp Clark stated that the design was his own but that he would make no charge to the Government for its use. The stamp was adopted on Clark's recommendation. Thereafter Clark filed application for patent and assigned to Solomons. A few days after issuance of the patent Solomons notified the Commissioner of Internal Revenue that the patent belonged to him and that he would like to arrange for proper compensation for use of the stamp on whisky barrels. Not receiving a reply, Solomons brought suit. The petition for compensation was dismissed on the ground that the United States had a license.

I wish to call particular attention to this case and to the fact that the court held that the United States had a license, which holding was amply warranted by the facts in the case. The court did not say that the facts in this case entitled the Government to an assignment, as is so often asserted.

Lane and Bodley vs. Locke (150 U. S. 193), is another case in which the acts of the employee were sufficient to raise the presumption of a license to the employer.

Gill vs. United States (160 U. S. 426), is also a case in which the findings were based largely on the findings in the Solomons case (*supra*). In this case also the petition for compensation was dismissed because of an implied license.

Wilson vs. J. S. Wilson Corp. (241 Fed. 494) is a case of implied license but in this case complainant was employed by the corporation as its chief engineer, charged especially with the duty of developing its business and keeping its products abreast of the times, and his patents were secured at the sole expense of the corporation.

Barber vs. National Carbon Co., 129 Fed. 370, is another case of implied license. In this case also Barber, employed as a mechanical engineer, was charged with the duty "to devote his time and skill to the improvement and cheapening of the process" of making carbon. A decree directing assignment was asked for in this case but was denied.

In Pressed Steel Car Co. vs. Hansen (137 Fed. 403), Hansen was employed "to improve and assist in improving the manufactured products of the company" and also among his duties was "the matter of devising, designing cars, or parts thereof." A bill to compel Hansen to assign was dismissed.

Hapgood vs. Hewitt (119 U. S. 226), is a similar case in which the bill to compel assignment of the patent was dismissed; Hapgood and Company having a license only.

In Hulse vs. Bronsack Machine Co. (65 Fed. 864), Hulse signed an agreement when he entered the employment of the company that if he made any improvements in the machine (for making cigarettes), either while in the company's employ or at any time thereafter, the same should be for the exclusive use of the company. The court held an invention made by Hulse to be the property of the company.

In Standard Parts Co. vs. Peck (44 S. C. R. 239), it was held that when one is employed to "devote his time to the development of a process and machinery for the production of the front spring now used on the product of the Ford Motor Company," and was to receive therefor a stated compensation, the improvements invented by him belong to the employer.

Considering these last few cases in some of which bills for assignment were dismissed, and in two of which, Hulse vs. Bronsack Machine Co. and Standard Parts vs. Peck assignment was decreed, let us see what underlying principle there is that distinguishes the one from the others. In those cases in which the bill was dismissed the inventor was receiving his wages in return for services as an engineer, designer, mechanic, etc., *and not for his services as an inventor*. The consideration moving the employer to pay him money was not invention. In the Hulse case a contract to assign inventions had been entered into by Hulse, and as this was a valid contract he was required to abide by its terms. In the last case, Standard Parts vs. Peck, invention and invention alone was the consideration given in return for the stipulated salary.

From all this it should be clear that the occasions on which the usual government employee's invention would become the property of the government must be very rare indeed, since the employee never signs an agreement when entering the service to assign his inventions nor is he employed as an inventor receiving his wages in return for an invention.

There are some few who seem to think that the assignment of a government employe to specific duties from which an invention results gives the government a right to an assignment of the full title to this invention and patent that may issue thereon.

To make such a view tenable one would have to contend that every time a government employe is assigned a new task it amounts to a new employment and that, consequently, the assignment to a deevlopment task which results in invention, is a new employment of the employee solely for the purpose of inventing. This, of course, is not the case as the employee still receives his old salary; is still working under his old civil service appointment, and still retains his old designation as draftsman, designing engineer, or what-not.

To sum up, a government officer, or employee, has as much right as anyone else to apply for and receive letters patent on his inventions and discoveries.

The property right of an officer or employe of the government invested in patents may not be taken from him any more than from any other citizen.

An officer or employee of the government may, like any other employee or officer, relinquish certain rights to his employer, amounting to a license, either by his acts or by the circumstances under which the invention was made.

He cannot, except by a clear and positive agreement, relinquish his complete rights in his invention and in any patents that may be secured thereon.

Finally, there is no authority in law, in so far as I know, that gives any one authority to compel an officer or employee of the government to relinquish his rights under his patent, or to prevent him securing a patent on his inventions.

RESERVE THIS DATE
OCTOBER 8, 1926

The 8th Annual Meeting of the Army Ordnance Association
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Books

Molybdenum, Cerium and Related Alloy Steels. By H. W. Gillett and E. L. Mack. American Chemical Society Monograph Series. New York: Chemical Catalog Company, Inc. 1925. $4.00.

THE growing importance of molybdenum as an alloying element in engineering steels warrants the attention of American steel makers and users and makes particularly acceptable the presentation of such an excellent collection of data as contained in this volume.

The present alloying elements are, in general, of foreign origin making the development of a domestic alloying element of obvious importance to the American steel industry. The largest deposits of molybdenum ore in the world are found in Colorado, there being sufficient to produce approximately 100,000 tons of molybdenum or twenty million tons of molybdenum steel.

The authors regard a given alloy steel as "a member of a class rather than a special entity," and consider the effect of heat treatment and substitution of alloying elements in the production of steels which may be interchangeable in application.

Chapters are included discussing the effects of alloying elements as a class and as individuals. Molybdenum and cerium alloy steels are considered in detail and compared with other alloy steels. The summary of the effects of molybdenum and cerium as alloying elements, concludes that cerium appears to have no true alloying effect but probably does harm since it gives rise to inclusions, while molybdenum is to be regarded as a very efficient alloying element. The properties of molybdenum steel compare favorably with the properties of other alloy steels.

This volume fills long existing gaps in the literature upon molybdenum and cerium steels.

G. P. WILHELM.

American Malleable Cast Iron. By H. A. Schwartz. Cleveland: The Penton Publishing Company. 1922. $7.00.

THE scientific press has discussed malleable cast iron, especially during the World War, at considerable length, but no one, for the last ten years, has assembled the up-to-date information on the subject for ready reference into one good book. The author of this book has not only digested and arranged all the historical, chemical, physical, electrical and manufacturing data on malleable cast iron, but has taken the trouble to add a somewhat complete discussion of the metallurgy of iron and steel, showing the place of the malleable types in this metallurgy as well as the effect of impurities and alloying materials. The book is, therefore, a satisfactory library for the malleable iron industry, superseding more than a five-foot shelf of technical magazines and books.

To give some idea of the extent of his treatment of the subject, he has forty pages of historical matter on American and foreign development of the malleable industry; thirty pages on metallurgy; one hundred and thirty pages on the actual foundry practice with various types of furnaces, both heating and annealing, in turning out the best quality of malleable iron; a short chapter on pattern making and molding; another on cleaning and finishing; another on inspecting and testing. He then proceeds to discuss the physical properties of the malleable metal from every standpoint for nearly ninety pages; gives an additional chapter on the thermal and electrical properties of the malleable products. He includes seventeen pages of bibliography, which must cover nearly the whole malleable field, certainly a bibliography which should be a basis for a full library on this subject. He has indexed the book for ready reference.

Particular praise must be given for the illustrations which are included. There are one hundred and ninety of them, scattered throughout the book where they belong. The microphotographs are well printed and described to illustrate the subject matter to which they pertain.

The book shows the result of an exhaustive research into the field of malleable iron casting and an orderly setting down of what his research has revealed, and, outside of that he brings to the text a knowledge of the industry and the uses of malleable cast iron which should make the book an authority on the subject. It should be a very valuable addition to the literature of the Technical and Design Sections of the Ordnance and industrial establishments.

C. G. METTLER.

The Builders of America. By Edwin Wildman. Boston: L. C. Page & Company. 1925. $2.00.

THE reading public has lately been favored with a number of volumes of an historical nature which give interesting sidelights on men and happenings of American history not hitherto included in volumes of their kind. A notable case in point was the monumental work of former Solicitor

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General of the United States, James N. Beck, in his volume "The Constitution of the United States." Mr. Edwin Wildman, whose name is already well known in connection with the "Famous Leaders Series," wherein he has previously described leaders of industry, character and American history, adds a very worthy contribution in his "Builders of America."

Ostensibly this book is for youthful perusal. As a matter of fact, it is worthy of veteran study. Gather together in one place short biographical and historical sketches of Madison, Clay, Monroe, John Quincy Adams, Clinton, Fulton, Webster, Biddle, Jackson, Van Buren, Astor, Irving, Vanderbilt, Harrison, Polk, and Pierce, and you have, as in this work, a truly representative group of American builders, political, literary, economical and governmental. Whether one has an insatiable appetite for the book of history or not, there is a great deal in Mr. Wildman's volume which, in justice to himself, every lover of America should know.

J. L. Aspinwall.

A Graphic Table Combining Logarithms and Anti-Logarithms. By Laeroix and Rogat. New York: The Macmillan Company. 1925.

THIS handy volume contains graphic tables giving directly, without interpolation, logarithms to five places of all five-place numbers and the numbers to five places corresponding to all five-place and four-place logarithms. The arrangement is quite novel. It is unnecessary to describe the awkward procedure in consulting the standard tables of logarithms. The authors of this book have combined in one graphic scale all five-place numbers and all five-place logarithms, either one of which can be read directly in terms of the other without interpolation. This simple procedure eliminates auxiliary tables of proportional parts and because of the accuracy of the results obtained makes the use of this system convenient, rapid and reliable.

We believe that the work of Lacroix and Rogat will find enthusiastic followers both among students and engineers who have occasion to consult logarithmic tables.

L. A. Codd.

Practical Microscopical Metallography. By Richard Henry Greaves and Harold Wrighton. New York: D. Van Nostrand Company.

THIS book considers the structure of metals and industrial alloys from the standpoint of "Constitution, with special reference to their mechanical properties and practical utilities."

The first two chapters are devoted to the preparation of specimens and the technique of making micro-examinations. Attention is directed to practical difficulties that may be encountered and results of faulty technique are shown by photomicrographs. These chapters are especially valuable in improving the technique of the operator.

Chapters are included upon the structure of pure metals and of alloys; the structure and properties of ingot iron, wrought iron, normalized and annealed carbon steels, hardened and tempered carbon steels, alloy steels, pig iron, cast iron, malleable iron, alloys of copper with zinc, tin and aluminum, aluminum alloys, zinc alloys, and bearing metals. The effect of impurities in copper, and non-metallic inclusions and defects in steel are also discussed.

Photomicrographs are shown under each subject adding greatly to the value of the volume as a reference book. There is included an index to all photomicrographs.

The book is intensely practical and will prove of interest and value to every one concerned with the properties and uses of metals.

G. P. Wilhelm.

Platinum Metals. By Ernest A. Smith. New York: Isaac Pitman's Sons. 1923. $1.00.

THIS little book is one of the "Pitman's Common Commodities and Industries Series," intended to give broad general scientific information in an understandable manner concerning useful commodities. Although the book deals primarily with platinum, as indicated by the title it also covers the lesser known associated metals, iridium, osmium, rhodium, and ruthenium. An interesting historical discussion is followed by sections on occurrence, distribution, sources of supply and production. The methods of mining and metallurgical treatment of the crude platinum are discussed, and special attention is given to the subject of properties and industrial uses of these interesting metals. Thirty-five illustrations serve to add materially to the interest of the text.

In view of the fact that platinum has developed in a few years from a metal hardly known outside of the laboratory, into a place of prominence in the jewelry industry, the general reader should welcome an opportunity of learning the interesting facts so well presented in Mr. Smith's book.

C. G. Storm.

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Warfare by Land and Sea. By Eugene S. McCartney, Ph. D. Boston: Marshall Jones Company. 1925.

"WARFARE by Land and Sea," which, by the way, is No. 33 in the library of books called "Our Debt to Greece and Rome," should be appreciated by those who have neither the time nor the opportunity to study more than briefly the military history of ancient Greece and Rome. Though written by a layman, it could not have been better done by a member of the military service. The author has given enough history to localize events and show the application of general principles, and he has then traced their application to modern battle conditions. It is not generally realized that the same tactical principles have been involved in certain modern battles as were first utilized by such great captains as Alexander, Hannibal, and Caesar. The relation between leadership and successful command in battle is clearly indicated throughout the text.

Some of the more important chapters in the book are the second, called "The Evolution of Generalship"; the fifth, called "Shock and Fire: The Development of Artillery"; the sixth, called "Greek Contributions to Tactics and Strategy"; the eleventh, "Roman Contributions to Tactics and Strategy"; and the thirteenth, "Ancient and Modern Analogies."

Mr. McCartney has gotten up a very readable account of the equipment, organization, tactics, and strategy of ancient armies, and this book will be enjoyed by everyone whether in or out of the military service.

"Warfare by Land and Sea" is a small volume, but it is nevertheless complete with a table of contents, a military and naval bibliography, and a list of the many quotations used in the text.

G. P. Wilhelm.

Scientific Research and Human Welfare. By Franklin Stewart Harris and Newbern I. Butts. New York: The Macmillan Company. 1924. $3.00.

IN his preface to this unusual book, Dr. Harris says: "The following chapters record some of the romance, not of the efforts of kings to win the hands of fair princesses or to extend their domains, but of the conquest by man of the forces of nature." Each of the fifty short chapters is a story filled with the romance of facts, and few readers will lay aside the book for any thrilling romance of fiction. The stories are those of the wonderful discoveries and inventions of scientific research, which have given us the conveniences and luxuries of the present day, told in an entertaining manner and in plain, every-day language. The chapters are grouped under the general subjects: health, communication, transportation, illumination, agriculture, engineering and mining, manufacturing, and the home. With such a diversity of subjects no one could fail to find something to attract his interest, and having read one chapter, he is certain to read them all.

In carrying out their laborious task of collecting the large amount of data presented in these stories, the authors had a higher object than furnishing entertainment—the awakening of increased interest in research. "If expenditure for research is stimulated by this record, then the work required in preparing it will be justified."

C. G. Storm.

Ten Years After. By Philip Gibbs. New York: George H. Doran Company. 1925. $2.50.

SOME of the best analyses of post-war psychology have come from the pen of Philip Gibbs. "Now It Can Be Told" not only pleased but by its deliberate and straightforward statements startled many staid and sober readers who were ill prepared for its contents. "Ten Years After" comes today as one of the most forcible expressions of national psychology and national indifference, if you will, of all the writings that have appeared since the War.

Given a man of the intellect of Gibbs with his world-wide viewpoint and his rare experiences both during the War and since, it is difficult to see how any other production could result once his fertile mind and facile pen have attempted to state the problem. The book he has produced does not fall short of the highest anticipation. It is one of those clear-cut, gripping treatises which perforce must make many of us stop and think and in the long run admit with shame that we are not quite as idealistic today as we were ten years back. If you will take up Gibbs' book and have him picture for you the turbulent days of 1914-1918 when patriotism was carried to its highest pitch and men were willing to sacrifice all for an ideal, and then have him relate the pitiful aftermath and gigantic fizzle in which the whole thing has resulted, our own national plight as well as that of the other so-called victorious allied and associated powers will make many thinking people stand in awe.

The author states the case of describing, as only Gibbs can describe, the scenes he witnessed in England and at the front when success for the Allied cause seemd far from obtainable. His description of the ardor and enthusiasm with which that cause won support from the manhood of England and its possessions must stand for all time as a worthy commentary on a brand of patriotism which perhaps will never again be equalled. He is sufficiently familar too with the American viewpoint to describe adequately our pre-war feelings in the matter, and he does not hesitate to give praise where praise is due.

Over and above all this, however, his description of what has taken place since the war, the shattering of ideals, the changes that have come about, and the apparent disregard of many principles and tenets that in 1918 were regarded as of the highest importance, will stand for years as a perfect statement of the case.

There are many, especially in America, who may not share the conclusions of Philip Gibbs. Whether they outnumber those who will agree with him is a problem, but this much is sure, he reviews a decade of history which has few parallels for any student of national psychology and he states the case with a frankness that will cause even some Americans to wonder whether or not the course we have taken in world affairs, in view of our explicit commitments during the War, is quite a position which we or posterity will look upon with favor. L. A. CODD.

The Next War. Addresses by Norris F. Hall, Zachariah Chafee, Jr., and Manley O. Hudson. Cambridge: Harvard Alumni Bulletin Press. 1925. $1.00.

ONE always looks rather dubiously in this day and age on speculations which have to do with the future. The age of the prophets has passed, and he who essays to tear

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away the veil often lays himself open to ridicule. Consequently, it is with some wonder that we open this book and find that three gentlemen at a Harvard University symposium have sought to give us an idea of the nature of the next war.

Professor Hall, who is an instructor in chemistry, examines the material means for seeking a decision in the next conflict. The importance of aircraft and their possible uses fill several pages and then come gases, tanks and other developments of the World War. The author allows his imagination full play and paints a dreadful picture of what might transpire. We wonder whether he has not stretched his imagination a little further than the industrial strength of the present world powers would warrant.

Professor Chafee deals with the conscription of public opinion. He shows the power of well directed propaganda and the ease with which a people can, under the cloak of patriotism, be prepared to accept war by their government. He thinks this attitude on the part of government should be changed and emphasis placed on international good will rather than hostility to foreigners.

The importance of propaganda after war has begun for blackening the enemy and deceiving one's own people is discussed as are also the dire results possible under a drastic espionage act where suppression becomes the motivating force.

Professor Hudson does not attempt to speculate on the next war lineup of peoples in his discourse called, "Stacking the Cards." He takes the view that the next war is not inevitable. The League of Nations may prevent it and even if it does not, the issues will be more clear cut than in 1914. He is an advocate of the League of Nations as a means to organize the world against the next war.

E. E. MacMorland.

Our Naval Heritage. By Fitzhugh Green, U. S. N., F. A. G. S., M. Sc. New York: The Century Co. 1925.

THIS book is a very complete and interesting historical narrative of the American Navy and Merchant Marine. The author speaks with a voice of authority and makes his history read like a story. It is presented in a style free of technical terms.

To the laymen this work is especially interesting, as it contains so many true stories which read better than fiction.

The author starts his work very dramatically by stating that it cost Columbus $2,115 to discover America. Among the maritime miracles quoted is an instance where one man sailed a full rigged ship for three months. In another case a full rigged ship of the line disappeared in calm weather with all hands on board. He also gives that celebrated story of the Marie Celeste, the mystery of which has never been explained. This ship was found under full sail with no one on board and four half eaten breakfasts on the cabin table. There was no evidence of foul play or accident of any kind. All was intact and perfectly arranged.

Altogether this is a very readable book, well illustrated and indexed. The volume is large enough to permit the use of readable type. It is to be regretted that there are not more books of this nature, dealing with American Naval and Military history.

G. P. Wilhelm.